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FISHERMEN BATS OF THE CARIBBEAN REGION

BY E. W. GUDGER

This paper is concerned with the fish-catching activities of certain bats found in the northern equatorial part of the New World. It has been definitely shown (Gudger, 1943b) that the Indian false vampire bats (genus *Megaderma*) have, since 1844, been known to eat fishes—fish remains have been found under their roosting places. They have not been seen in the act of catching fishes, but to eat fishes they must catch them. It has also been alleged that the Indian flying foxes (genus *Pteropus*), when skimming over a pond, catch fishes and later eat them, but evidence from dissected stomachs is entirely negative. It has been demonstrated that the North American bat, *Pizonyx*, is also a fish-eater (Gudger, 1943a). This peculiar bat has been found only under stones in three small islands in about the west central side of the Gulf of California. The present article sets forth the evidence that the American hare-lipped bat, *Noctilio leporinus*, has long been known to be a fish-catcher and fish-eater.

The piscivorous bats of the New World were all primarily insectivores and, indeed, they still take insects on occasion even though their taste for fishes is well developed. This is true despite the fact that in various localities fishes certainly predominate in the diet of these Chiroptera. How this habit has come about will be considered and an explanation suggested after the facts have been brought forward.

THE FISHING BAT OF ECUADOR

The first intimation found that American bats feed on fishes is contained in a systematic paper by Tomes (1860) on a collection of mammals made in Ecuador in western equatorial South America. The bat is *Noctilio leporinus*, the rabbit-nosed night-flying bat (pl. 1, fig. 1). All the mammals listed in Tomes' paper were taken in Ecuador by a Mr. Fraser, long a collector in northern South America for the Zoological Society of London. Of the habits of the bat of the species named, Fraser wrote: "Esmeraldas [Ecuador], November 1859; skimming the bank of the river, every now and then making a dash along, and actually striking the water, catching minute shrimps as they pass up the stream. He had a very offensive fishy odor."

FIG. 1

FIG. 2

PLATE 1

FIG. 1. Head of *Noctilio leporinus*, the hare-lipped bat. Note the alert ears and especially the divided upper lip, which gives this bat its specific name. Enlarged to twice natural size. After Harting.

FIG. 2. Noctilio flying over water; has caught a fish where the water is disturbed. This it did with the claws of its right foot. From Goodwin.

This odor of course indicates persistent fish-eating. It is well known that most bats have an unpleasant odor, but, strange to say, in the literature of fish-eating bats, Tomes' reference to this fishy odor is a solitary one. Mr. George Goodwin, Associate Curator of Mammals in the American Museum, tells me that noctilios captured in a cave near San Juan, Porto Rico, had a most dreadful and overpowering odor. Though this was not distinctively fishy, it was thought that fish had contributed to it. Other noctilios taken in the open at St. Thomas had only a mild musky odor.

On the aquatic habits of this Ecuadorean bat, Tomes comments as follows: "This is the first recorded instance which I have met of any species of Chiroptera being actually aquatic in habits. . . . I had long ago been led to suspect that that bat might be aquatic in its mode of life, but I could never gather direct evidence on the subject. Certainly I little suspected that this Noctilio took its food in the manner noticed by Mr. Fraser."

The above citation, buried as it is in the text of a systematic paper on a collection of mammals from Ecuador, has long been overlooked by the few who have studied the fishing habits of bats.

THE FISHERMEN BATS OF MONOS ISLAND

From Monos, a little cavernous limestone island measuring about $2\frac{1}{4}$ miles long by $1\frac{1}{2}$ wide, have come more accounts of fishing bats than from all the other parts of the world together. It would seem that all the bats that inhabit the caves of Monos sooner or later go a-fishing for their living. Apparently they have largely given up insects as food and largely make fishes their *pièce de résistance*. As may be seen on the chart (fig. 1), Monos lies just off the northwestern corner of Trinidad in the strait of the Dragon's Mouth (Boca del Dragón). All these Monos Island fishermen bats, like those from Ecuador, belong to the genus and species, *Noctilio leporinus*.

First Account, 1871.—The first account of the fishing bats of Monos was published by Charles Kingsley (1871) in his delightful book "At Last." Kingsley spent most of his time (on his visit to this region in 1869–70) on Trinidad and in charming fashion wrote of the multitude of fascinating natural history phenomena that he saw and of the incidents of which he was a part. Among these is his description of a trip early in January 1870 to Monos Island, which, as the chart shows, is the first of three stepping stones between the island of Trinidad and the peninsula of Paria, jutting out from the mainland of Venezuela.

In trying to reach and circumnavigate Monos, Kingsley's experiences with the turbulent currents in the Bocas are recorded in words that well describe them. He speaks of "a tumbling swell", "columns of white spray", "a waste of breakers . . . leaping, spouting, crashing, hammering . . . with a wild uproar". And, save under a favorable conjunction of wind and tide, these conditions prevail today to the hampering of efforts to study the fishing bats of this island. Kingsley was successful here, however, and of that one of his various experiences at Monos he wrote as follows:

> As the sun sank that evening, we sat ourselves upon the eastern rocks [of Monos] . . . while Venus hung high . . . throwing a long gleam over the sea. Fish skipped over the clear

calm water; and above pelicans . . . paused, gave a sudden half turn, then fell into the water . . . and after a splash rose with another skipjack in their pouches. As it grew dark, dark things came trooping over the sea, by twos and threes, then twenty at a time, all passed us toward a cave near by. Birds we fancied them at first . . . but they proved to be bats, and bats too that have the reputation of catching fish. So goes the tale, believed by some who see them continually and have a keen eye for nature, and who say that the bat sweeps the fish up off the top of the water with the scoop-like [interfemoral] membrane of its hind-legs and tail. For this last fact I will not vouch. But I am assured that fish scales were found, after I left the island, in the stomachs of these bats; and that of the fact of their picking up small fish there can be no doubt.

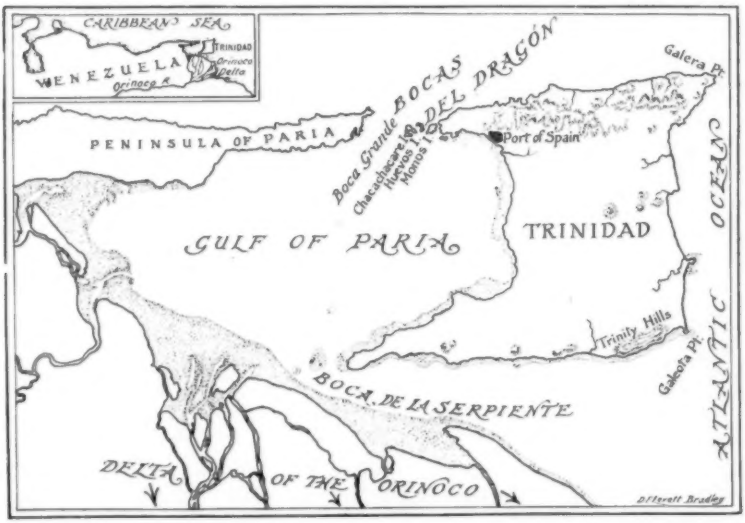

FIG. 1. A chart showing Trinidad, the Serpent's and Dragon's Mouths, the Gulf of Paria, the Peninsula of the same name, and the Orinoco delta. Note the three islands with their bocas constituting the Bocas del Dragón. Redrawn from a chart presented by the United States Hydrographic Office.

Second Account, 1888.—In "The Field" (London) for July 14, 1888, there appeared a note entitled "Change of Habit in Animals", signed "The Doctor". This was written to tell that:

On the opposite side of the strait, or Boca [of Monos Island] is another cavern . . . which is the roosting place of a colony of large bats with wings and teeth perfectly fitted for insectivorous living. What do they do? Give up insect-hunting and go a-fishing. They came out in the gloaming, and fluttered and splashed on the top of the water, and somehow or other caught tiny fish. I floated about many a hot evening to see how it was done; but . . . I could never quite make up my mind on the subject. On the whole, I was inclined to accept the native idea that they scoop them off the surface with the interfemoral membrane. However, . . . they certainly *did* catch fish, and eat them; for I found fish-scales and bones in their stomachs, and had microscopic slides prepared to prove it.

It is very difficult to see a rapid-flying small bat (about four or five inches long, and with a wing-spread of twelve to fifteen inches) scoop out of a school of small fry an individual fish, especially in *twilight*. But in these slides was something to go upon, an effort to demonstrate by a microscopical examination of their stomach contents that these bats eat fishes. However, the well-known naturalist, J. E. Harting, reported in "The Field" for April 6, 1889, that an examination of the "Doctor's"[1] slides by the distinguished ichthyologists Day and Günther, showed that the bright fragments in them were not the scales of a fish but the wing cases of an insect.

Third Account, 1889.—Fortunately Harting was not content with the negative outcome of the microscopical examination, but was intent on going to the bottom of the matter. He appealed to the governor of Trinidad for specimens of the alleged fish-eating bats and for reports of their activities. This request was passed on to Prof. McCarthy of the Government Laboratory in Port of Spain, whose materials and reports effectually settled the matter that *Noctilio leporinus*, of Monos Island, not only feeds on insects but also on fishes.

McCarthy sent to Harting three separate consignments of freshly-killed bats preserved in alcohol, microscopical slides of his own preparation, and careful reports of his observations on the living animals and of his examinations of some of the material he procured. I quote from McCarthy's reports to Harting (1889):

> On December 29 [1888] I proceeded to Monos and . . . visited a cave on the east side of the island of the first Boca. . . . The bats were then in an active state and . . . appeared to be flying homewards. There were few fish near the surface of the water and comparatively little local fishing appeared to be going on. An occasional 'swish' now and again far out proved that the bats were trying to secure their prey. Five homeward-bound [bat] specimens were secured in the cave about twelve yards from the mouth. The stomach of one specimen, opened within a half an hour, contained much fish in a finely divided and partially digested state. . . . On the morning of the 31st I visited the cave from which specimens were procured at 3 a.m. . . . The bats . . . came flying in dozens and two specimens were secured. Both contained considerable quantities of fish. . . . I have opened several other specimens of the bats, and in the majority of cases fish scales were found.
>
> My opinion from what I have ascertained (though I have not actually *seen* the operation, I have *heard* it) is that the bats skim the surface peering at the same time into the water below. As soon as fish are observed, the interfemoral membrane is let down, and occasions the "swish" so frequently heard. At this time the fish is secured by the claws immersed in the water, and is possibly raised with the assistance of the membrane, and so held until the mouth is reached down below the body and the fry devoured. I am inclined to attach more importance to the use of the membrane as a means of coming to a sudden stop, than as a lifting medium which may possibly be done or assisted by the wings. It is believed that the fish are sometimes lifted out by the membrane alone being employed as an impervious net.

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[1] The "Doctor" (G. H. Kingsley, a brother of Charles Kingsley) quoted above was surgeon on the *Northumbria* on cruise in the West Indies. Thus eighteen years later he retraced at Trinidad the footsteps of his famous brother, went to Monos and made his observations in the very same Boca that his brother had visited.

So much for the naked eye observations of Prof. McCarthy and the conclusions drawn therefrom. To illustrate these and other observations and conjectures, an interesting figure is reproduced here that the reader may get a visual interpretation of this fish-catching (pl. 1, fig. 2). But McCarthy went further than conjecture and examined some of the excreta of the bats for fish remains, but found only insect fragments—in accord with the known fact that Noctilio is an insectivore. However, it must be recalled that he sent to Harting freshly killed bats in alcohol. Examination of their stomach contents revealed the presence of fish scales and fin rays. And in one of the prepared slides sent from Trinidad, there was found the lower jaw with the teeth of some small fish. Other slides showed muscular tissue and oil globules—all judged to have come from the fishes eaten.

FIG. 2. Hind foot of a fish-eating *Noctilio* from Monos Island. Note the long toes and the long recurved claws used for gaffing the little fishes. Enlarged; natural size $1\frac{1}{16}$ inches long. After Harting.

Harting was so impressed with McCarthy's remark that the foot is more likely than the interfemoral membrane to be the organ with which the fishes are taken, that he had a drawing made of the foot and this also is reproduced for this article (fig. 2). Of it Harting remarks, "The large and powerful hind foot figured might well perform the office attributed to it in seizing the fish, either with or without the assistance of the interfemoral membrane." This foot with the toes ending in sharp recurved claws, as the figure shows, is certainly fitted for grasping and bringing from the water any small fish. This is apparent and the figure shown is accurate, as I have found by examining numerous dried specimens of *Noctilio leporinus* in the American Museum. These sharp recurved claws are very like small barbless fishhooks, and could easily serve for gaffing small fishes.

But the question may well be asked: "Is the bat provided with masticatory apparatus sufficient to chew up or at any rate tear into fragments the scale-covered body of a fish?" Harting answered this query also by giving a figure

of a skull and lower jaw of our *Noctilio* drawn twice natural size. This is also reproduced here (fig. 3). Now long ago Gosse had fed cockroaches to one of these *Noctilio* bats and had seen and heard it crunch the heavy chitinous exoskeleton and body of the insect with ease and with relish. There can be no doubt that such jaws armed with the pointed teeth shown in the figure could dispose of the thin scales and tender tissues of a small fish.

So now it was definitely proven that the insectivorous bat, *Noctilio leporinus*, is also a catcher and eater of fishes. Later confirmatory accounts will be given, but before going to these it will be of interest to give Harting's measurements of one of his bats. Its length from tip of nose to the end of the extended femoral membrane was 5½ inches; the head and body only were 4½ inches long; the hind

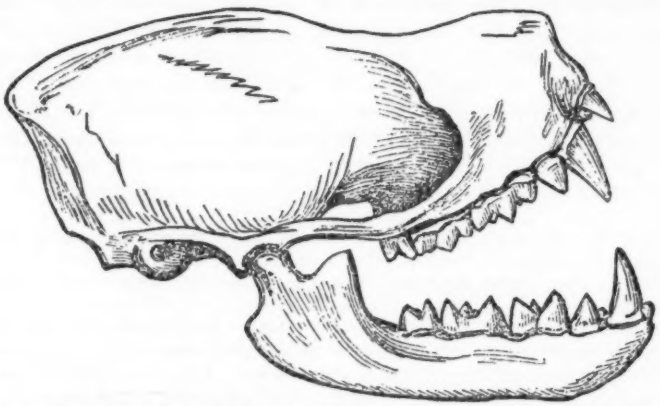

FIG. 3. Skull and jaws of the Monos Island fish-eater, *Noctilio*. Note the large pointed canines for grasping and the sharp multi-cusped molars for cutting insects and the scale-covered fishes. Enlarged about 3½ times. After Harting.

foot measured one inch; and the expanse of the wings was 16 inches. It is to be regretted that he did not have a drawing made of the whole animal instead of the head only (pl. 1, fig. 1).

Fourth Account, 1893.—McCarthy's efforts to solve the mystery of the fish-eating bats of Monos Island and Harting's publication of these reports stirred the naturalists at Port of Spain to further observations and at a meeting of the Trinidad Field Naturalists' Club on June 2nd, 1893, two of these bats from Monos were presented to the Club. Then the President, H. Caraccioli (1893), "described the manner in which the fish-eating bats captured their prey . . . by throwing it up with the interfemoral membrane. Simultaneously they bent their heads towards their tails to seize the fish as it was thrown out of the water".

Then there evidently followed some discussion and "Dr. Woodlock said that early one morning at Monos he distinctly saw the bats in this act and was sure that they caught fish and that the bats were not merely dipping into the water." Here then is more eye-witness evidence to confirm that by dissection showing the presence of fish remains in the stomachs of the bats.

Fifth Account, 1893.—Allen and Chapman (1893) described two noctilios taken in the Dragon's Mouth but not in the Boca between Trinidad and Monos. Then Chapman quotes the interesting observation from his field notes that "The cave on the eastern side of Monos Island . . . seems now to be deserted by them". His specimens came from cavern-like fissures in the rocks on the west side of Monos, facing the Huevos Boca. Of these bats he states that "Their stomachs contained the partially digested remains of fish; confirmation . . . of the now well-known fish-eating habits of this species". Then this keen observer queries, "Is it not possible that the much-lengthened, curved, acute toenails of this species are of assistance to it in catching or hooking fish?" This is interesting because Dr. Chapman independently set out this conjecture in the same year (1893) as Harting—and entirely independently of him. This adventure is also recounted in Dr. Chapman's delightful autobiography (1933).

Sixth Account, 1926.—It is a far cry to the next report on the fish-eating bats of Monos Island. Yet the observations were made ten years before those by Chapman, but were long unpublished. In the winter of 1883–84, J. E. Benedict (1926) was naturalist on the "Albatross" while she made soundings in the Caribbean Sea. During his stay at Trinidad, Benedict went to "Mona [sic] Island", and thus described what he saw.

> **While on the way, many pelicans were seen fishing off the sea cave, and in aiming at schools of small fish many of these were disabled and floated dead or wounded on the surface of the water. Many rather large bats were flying about with the pelicans, occasionally gliding down to the surface, touching the water it seemed to me with the membrane between the legs and tail, and then ascending with a sharp turn. It appeared to me that they were fishing and had a community interest with the pelicans as it were, taking the crumbs which fell from their table in the form of dead or wounded fish. I did not actually see them take a fish, but they acted as if they were doing so. If not, why were they flying with the pelicans on a bright afternoon?**

Two points are of much interest here. First is that the bats fished in bright daylight. It would be interesting to know if they do so often. The second point is that they were fishing with the pelicans and on their "leavings". Neither observation has been recorded by any one else. Both these things will be referred to later. But did the bats really catch fish? Benedict could not actually see the operation, but to test the fact, he shot several of these dayfliers and "examination of the stomachs revealed the remains of fish exclusively."

Goodwin (1928a, b) published two interesting articles on bats. In these he briefly reviewed much of the literature on this habit in Monos bats, including Benedict's article. He also examined one of Benedict's specimens on deposit in the United States National Museum and found its stomach contents to consist of "Remains of fish, 100 per cent". In discussing Benedict's paper with me, Goodwin has suggested that since these bats catch large insects such as beetles, mole crickets, etc., on the wing, then it might be possible that some of the bats when flying among the pelicans, might catch some of the little fishes as they fell from the pelicans' beaks.

On a visit to Botany Bay, St. Thomas, American Virgin Islands, in May, 1926, Goodwin (1928b) made some interesting observations on the crepuscular activities of our noctilios. He watched them flying over a small freshwater pond and swooping down on the water, making loud splashes as if they were fishing. However, they visited the center of the pond, whereas the fishes were found in numbers along the edges. In striking the water "The interfemoral membrane seemed to be used to scoop up the water . . . they appeared to be drinking rather than fishing". Fifteen specimens were taken and the stomachs of five were examined but these contained only insect remains. Hence it would seem that they were not fishing. However, although Goodwin failed to find any fishes in the stomach of his bats, he did us the service of having had drawn the interesting picture (reproduced as pl. 1, fig. 2) of a bat which had just caught its fish with its right foot and claws.

A FISHING BAT FROM SURINAM

In the U. S. National Museum there is a bat (no. 15058), *Noctilio leporinus*, taken in May, 1881, by C. J. Herring somewhere in Surinam (better known as Dutch Guiana). This bat was examined by Goodwin in 1928 and in its stomach were found many insect remains and "of a fish—trace". One wishes for more specimens from Surinam and more stomach contents for examination. But at least this gives us another and a new locality for the fishing activities of Noctilio.

BAT FISHERMEN IN THE ORINOCO DELTA

South of Trinidad, Monos with its fishermen bats, and the Gulf of Paria, is the great delta of the mighty Orinoco. Here in 1908, Dr. William Beebe (1941) saw a small flock of bats seeking their suppers. Since no specimens were obtained, we cannot be sure of their identity but it may be presumed that they were *Noctilio*. He describes their activities as follows:

> Near the mouth of the Rio Guarapiche, we anchored about four in the afternoon. . . . Interesting creatures were the bats which came out as the swifts went to roost, and thus gave reason to our captain's belief that both were one and the same kind of creature. What I could hardly believe was the constant dipping of some of the smaller bats down and almost into the water after fish. I soon came to look for them wherever schools of small fry began leaping above the surface. Six or eight bats would instantly appear from nowhere, dash down, hesitate for a fraction of a second, or curve up without any delay. Sometimes there was scarcely a ripple, or again there would result a decided splash, and then afterwards the bat would flutter in mid-air, as if shaking off the water. Now and then one would dip to snatch a drink and this was quite different from the fishing swoop.
>
> Several times I saw the glitter of fish scales but I could not with complete certainty tell how they were caught. Twice a bat seemed actually to seize the small fish in mid-air as it jumped, but usually the position of the bat was obliquely upright, and the strong, gripping hind claws may have functioned. Whatever it was, the skill exhibited far excelled the similar activity of an osprey, and was consistent with a bat's facility in dodging obstructions and seizing its more usual prey in mid-air. I shot one to see if there were fish in its stomach or scales on its toes, but the moment the animal hit the water it was dragged under by something. However I distinctly saw a small and very bent fish floating away from the spot.

FISHING BATS OFF CAPE SAN BLAS, PANAMA

The next account that has come to my attention is found in Governor Gifford Pinchot's (1930) delightful book, "To the South Seas". On a night in May, 1929, while at anchor off San Blas, Panama, he had this interesting experience. He was awakened and brought on deck ". . . to see bats catching fish by the boat boom light". Here is what he saw:

> There was no wind and the water was still as a floor. Many little fish were breaking the surface. Large bats, about eighteen inches across the wings were flying all about. Every now and then one of them would swoop along the surface at high speed, leaving a long straight wake where its tail, edged with wing membrane and curved into a scoop, swept up the water, and I suppose swept up the little fishes. That at least is what it looked like. . . . When I first saw it I did not believe it myself.

No specimens were taken, but presumably these bats were *Noctilio*. This locality, on the Caribbean side of the Isthmus of Panama, and east of Colon, is in the range of our *Noctilio*. This account adds another locality and another observation to the growing record of Caribbean bat fishermen.

A FISHING BAT AT BARRO COLORADO, CANAL ZONE

For this locality we have but one authority and one account. Barro Colorado is an island-hill in the Gatun Lake section of the Panama Canal made by the encircling waters behind the Gatun Dam. On this is the Barro Colorado Tropical Laboratory, where Dr. Frank M. Chapman has made many fascinating studies of beasts as well as birds. At Monos Island on May 5, 1893, he had gotton proof that bats eat fishes. But he had to wait thirty-eight years before he saw the fishing as described in the following paragraph taken from his "Autobiography of a Bird-Lover" (1933).

> Shortly after dark, on January 3, 1931, near the mouth of the Wheeler Estero, Barro Colorado Island, by the combined light of a nearly full moon and a powerful focussing flashlight, I saw a large pale bat, about the size of a nighthawk, which it resembled in flight, course to and fro low over the still water within a few yards of our boat. From time to time it dragged the surface of the water with its spread interfemoral membrane, producing a soft, swishing sound which I heard before I knew its cause.

This bat was of course not identified, but it is presumably our night-flyer, *Noctilio*, which is found throughout this region, and it is probable that it was fishing. I have sought for other records from this locality, but unfortunately have found none.

This account is the last of the known published records of the fishing activities of bats in the Caribbean region. The bat fishermen of Ecuador, Monos Island and Surinam are known to be the form *Noctilio leporinus*. It is a fair presumption that the other bat fishermen referred to are also *Noctilio*. This bat is widely distributed from Cuba, the West Indies and Mexico to the La Plata region and all forms have the long, slender, curved, grasping claws—admirably adapted for gaffing small fishes from the surface of the water. As more observations are made of the habits of *Noctilio*, more specimens collected and more stomachs

dissected and their contents scrutinized, it may be confidently expected that many other localities will be listed for the fishing activities of bats of the genus *Noctilio*. Perhaps the publication of this paper, bringing together all known records, may help forward this study.

WHY DO BATS CATCH AND EAT FISHES?

The reader is asking why it is that bats, primarily and predominantly insectivorous animals, catch and eat fishes. Bats are warm-blooded animals and all the insectivorous ones feed on the wing. This calls for the expenditure of much energy. On the other hand, resting bats in our latitude will have a body temperature but slightly higher than that of the surrounding air and a respiration rate that is almost negligible. This calls for the expenditure of a very small amount of energy. But when active in the warm summer (on the wing 10 to 12 hours daily) a bat may have a body temperature as high as 104°–105°F., and its respiration rate must be correspondingly high. This calls for the expenditure of much energy. To supply this energy, the bat must consume comparatively large amounts of food.

Bats were originally insectivores, but it seems that insects, largely made up of chitinous parts, are a rather poor source of food energy for these very active animals. They must gorge themselves with insects to obtain the nourishment and energy necessary. Along this line, Goodwin tells me that he has captured bats so crammed with insects that their abdomens were tremendously enlarged.

Here are some exact facts. For over three months a German investigator in Hamburg kept a bat in a small cage where no flying was possible. He weighed the bat and its daily intake of food and found that the food it ate each day varied from 2 to 52 percent of its weight—the average being 26 percent. This is a huge intake, and the outgo—bat guano—is also large. If a captive and practically inactive bat daily ate so much, what must be the daily food intake necessary for a free bat on the wing 10 to 12 hours each day?

But why do insect-eating bats turn from their natural provender to fishes as a source of food? Because one little fish is in food value probably equal to at least one hundred small insects. Furthermore it is taken at one swoop with the expenditure of, say, one unit of energy, whereas the hundred insects would require one hundred units. We will leave out of the question our American sanguinivorous vampire bats, which for some hundreds of years have been known to feed on the blood of the large domesticated mammals, and of man himself, but which are not known to catch fishes. However, when we turn to the Indian false vampires, which also were originally insectivores, we find that as early as 1842 Blyth saw one on the wing catch and suck the blood of another bat and afterwards in a cage eat its flesh. Over the following 35 years, other students of the false vampires have proved that they eat not only bats but mice, birds, lizards, and, among aquatic animals, frogs and fishes. So much for the change of food habits in the most studied Old World insectivorous bat.

Turning now to the insect-eating bats of the New World, it has been proven that the *Noctilio* of Monos Island (and presumably of northern South Amer-

ica generally) and *Pizonyx* of the Gulf of California feed largely on fishes. In fact when they can get them, they seem to reject an insect diet in favor of an all fish one. Recall here Benedict's dissections of his 100 per cent fish-eaters at Monos.

The answer to the reader's question—"Why fish instead of insects?"—seems then to be this. Just as modern high-speed long-distance flying airplanes call for a high-grade, high-octane energy-producing gasoline, so at least some of the tireless-winged bats have sought for a higher energy-containing food and have found it in fishes with their oily flesh.

HOW DO BATS CATCH AND EAT FISHES?

Since all known fish-catching bats belong to the present-day insect-eaters, a description of how these latter feed may perhaps give us an idea how the piscivorous ones might go about getting their fish food. This insect-feeding is thus described by Allen (1939) in his interesting and invaluable book to which I am indebted for much and varied data:

> . . . the tail membrane plays an important part in the capture of prey during flight. Immediately a good-sized insect is seized in the jaws, this membrane is curved downward and forward to form a sort of pouch; at the same instant the head is bent down into this net to prevent the escape of the insect, while the grip of the jaws is momentarily relaxed to give several quick bites, disabling the insect and allowing the bat to chew it up with the sharp cusps and molars.

As the figures referred to in this and my other papers show, all these insectivorous-piscivorous bats have long sharp canines for seizing and holding their insect prey while their sharp-cusped molar teeth are fitted for cutting up the bodies of the insects. These teeth would do the same thing for scaly-bodied fishes.

Insectivorous bats not only feed on the wing, but, as many observers have testified, they also drink on the wing. When they skim over the surface of the water, they lap up water with the tongue or scoop it up with the lower jaw. At such times most observers have noted an audible "swish". At these moments it is possible that the curved stretched membrane throws up into the pouch water which is then lapped up. At such times it is also possible that an insect at or on the water might be thus caught up into the pouch. If an insect, why not a small surface-swimming fish? Then finding this good to eat, might not the bat try it again and again?

Insectivorous bats take their prey on the wing in the air, but piscivorous ones do not. Yet we must recall here Goodwin's conjecture that bats on the wing may possibly catch little fishes as they fall from the pelicans' beaks. However this might be, bats normally must take their fish prey out of the water or off its surface. But they do not use their jaws for catching fish. Furthermore, since bats fish at night or at best at twilight (note the one daylight account on a preceding page), this together with their speedy flight makes naked-eye observation practically impossible.

In the preceding paragraphs are found the basis for the first conjecture as to how the fish-catching habit arose. It would be easy for a bat skimming over the surface of water filled with a school of surface-swimming small fishes accidently to pick up a specimen in the interfemoral membrane and hold it there for a moment until it might be grasped by the jaws. Then it might be eaten as are the larger insects as described by Allen.

This conjectural method of fish-capture was the first to be suggested, and is today held by many, but another has been offered. In 1889, McCarthy wrote to Harting from Trinidad that his observations of the fishing by bats at Monos Island led him to believe that: "As soon as the fish are observed, the interfemoral membrane is let down and occasions the 'swish' so frequently heard. At this time the fish is secured by the claws immersed in the water, and is possibly raised with the assistance of the membrane and so held until the mouth is reached down and the fry devoured"—as is shown in Goodwin's figure above (pl. 1, fig. 2).

This conjectured combined use of interfemoral membrane and claws of the feet, in my judgment, offers the best suggestion as to how the fish are taken. But if a dried museum bat is held vertically with ventral surface toward the observer, the toes and claws are turned backward. This I found always in the specimens from the American Museum's large collection of noctilios from the West Indies and South America. I had thought that possibly the bat skimming at the surface of the water could pick up a little fish with these claws—but not if they are turned backward.

However, Goodwin tells me that in life these claws are turned inward, as he showed me they are in alcoholic specimens. Then referring to Benedict's account of bats fishing at Monos among the pelicans, Goodwin suggests that the bats as they skim over the water might with their inward-turned feet and claws grasp dead or disabled fishes at the surface of the water, as first conjectured by McCarthy. These are surely strong possibilities for the action of bats fishing among and with pelicans.

That the bats at Monos Island catch fishes is an assured fact, but the exact manner in which they do so has yet to be ascertained. The great need is for someone to go to Monos with proper moving-picture cameras and bide his time until the bats are fishing, if not in Benedict's "bright daylight", at least in light strong enough for the taking of moving pictures. Then when such a film is run through a slow-motion camera the exact method of taking the fish would be revealed. Some day someone will produce this proof.

HOW DO BATS LEARN TO FISH?

This question has partially been answered in the preceding section. The first involuntary picking up of a fish at the surface of the water by the interfemoral membrane or by the claws of the hind feet would provide such tasty nutritious food that other such efforts would doubtless be made and thus the habit would presently be established. Other bats having like experiences might also develop like habits.

But the reader is asking another and even harder question: "Does each new generation of adult bats at Monos Island and in the Gulf of California have for itself to learn anew to fish?" I do not know, but I have elsewhere presented proof that, among cats and dogs that go a-fishing, the old cats teach their kittens and the old dogs their puppies to plunge into the water and catch fishes. Perhaps the batlets are likewise so trained by their mothers.

SUMMARY

The bat is *Noctilio leporinus* and the first intimation that it or any other bat ate fishes dates back to 1860 when one was killed while skipping along a river in Ecuador. It was found to have an "offensive fishy odor."

From Monos Island, northwest of Trinidad, come six accounts of bats seen "fishing". Four men killed specimens fresh from the fishing and found their stomachs full of fish remains.

In alcoholic specimen from Surinam (Dutch Guiana) in the U. S. National Museum the food contents of the stomach were "100 percent fish".

"Fishing" has also been reported from the Orinoco delta, the San Blas coast of Panama, and from Barro Colorado Island, Canal Zone.

Fishing is done at twilight or at night, but one (Monos) report says in "bright afternoon".

Bats catch fishes for the highly nutritious food, crushing the scaly prey with their sharp-cusped teeth.

The fishes are caught in the interfemoral membrane or by the hook-nailed toes of the hind feet, or by both, as the bats swoop over the water.

They probably learned to fish by accidentally catching fish at the surface of the water when seeking aquatic insects. Finding fishes probably more palatable than insects, they tried again and again.

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Department of Ichthyology, American Museum of Natural History, New York.

TRAVELS OF BANDED CAVE BATS

BY DONALD R. GRIFFIN

This paper is intended to supplement an earlier one (Griffin, 1940a) describing a study of the migrations of cave bats by the banding method. The late Dr. G. M. Allen was constant in his encouragement and constructive criticism of this project. Over 13,000 bats of six species (*Myotis l. lucifugus*, *M. keenii septentrionalis*, *M. sodalis*, *M. subulatus leibii*, *Pipistrellus subflavus*, and *Eptesicus f. fuscus*) were marked with small bird bands placed around their hind legs. All were captured in the New England states and New York. This paper will deal with all recoveries of these bats at 10 miles or more from the place of original capture. There were several recoveries at shorter distances, mostly less than 5 miles, but they do not seem worth describing in detail.

Most of the returns were obtained in the course of the banding operations, but many recoveries of banded bats were reported to the U. S. Fish and Wildlife Service, which issued most of the bands used and cooperated generously in relaying to the writer all reports from persons finding banded bats. Several such reports were useless because the finders did not read all digits of the band number, largely due to overgrowth of flesh which sometimes partly obscures the bands on bats' legs. Other methods of marking, such as the ear tags used by Mohr (1934), or possibly the wing bands used by Eisentraut (1936) and Trapido (personal communication) might avoid this difficulty because overgrowth is less frequent. Ear tags and wing bands have the further advantage that the marking is more conspicuous when the bats are hanging in dense clusters. Even with leg bands, however, the percentage of recoveries is comparable to that achieved in banding small birds.

Of the 13,000 bats banded, about 8,500 were collected during hibernation in caves, almost all of which were located in western New England or eastern New York state. Most of the bats taken in caves were *Myotis l. lucifugus*, but the other five local cave bats were also included. Only *M. lucifugus* and *Eptesicus f. fuscus* were taken at summer colonies (breeding roosts in buildings, consisting of females and young), and the former species constituted the great majority of the bats taken at these summer colonies.

TABLE 1.—*Foreign returns of banded bats secured 1939 to 1942*

SPECIES	SEX	BAND NUMBER	PLACE BANDED	DATE BANDED	PLACE RETAKEN	DATE RETAKEN	DISTANCE AND DIRECTION OF FLIGHT
M. sodalis	♂	H44551	C-3	Nov. 27 '36	C-5	Oct. 22 '39	66 m. S.
" "	♀	38-24932	C-3	Dec. 5 '37	C-1	Mar. 3 '40	35 m. N x E.
" "	♀	38-24934	C-3	Dec. 5 '37	C-1	Mar. 3 '40	35 m. N. x E.
M. l. lucifugus	♂	37-60205	C-1	Apr. 7 '37	C-4	Nov. 10 '37	156 m. S.
" " "	♂	37-60205	C-4	Nov. 10 '37	C-1	Mar. 3 '40	156 m. N.
" " "	?	38-62898	C-3	Nov. 24 '40	C-9[1]	Oct. 31 '41	66 m. S.W.
" " "	♂	37-61095	C-5	May 1 '37	C-9	Mar. 1 '41	61 m. W.N.W.
" " "	♂	38-24052	C-4	Nov. 10 '37	C-9	Oct. 13 '40	91 m. N.W.
" " "	♂	38-62289	C-8	Mar. 2 '41	C-9[1]	Jan. 27 '42	9 m. S.E.
" " "	♀	38-61448	S-4	Sept. 9 '39	C-8	Mar. 2 '41	21 m. E.N.E.
" " "	♂	38-61289	S-3	Aug. 4 '39	C-8	Mar. 2 '41	14 m. N.N.E.
" " "	♀	37-61900	S-1	June 19 '37	S-11	c. Apr. 25 '41	75 m. N.W.
" " "	♂	H41511	S-1	July 17 '35	S-10	Sept. 2 '41	42 m. N.W.
" " "	♀	37-61740	S-1	June 22 '37	S-9	July '42	158 m. W.
" " "	♂	37-60767	C-7	April 5 '37	C-6	Feb. 6 '38	8 m. W.

[1] Recovered by Mr. Charles Mason.

There were, in all, 39 recoveries of bats at a distance of 10 miles or more from the place of banding, and I have called these recoveries "foreign returns". They may be divided into (1) those captured during the same season as the date of banding, before a period of seasonal migration, and (2) those taken after at least one spring or fall migratory period. These groups I shall call "same-season" and "later-season" foreign returns respectively. Same-season returns may be from cave to cave or from summer colony to summer colony, while later-season

TABLE 2.—*Location of bat colonies in figures 1 to 4*

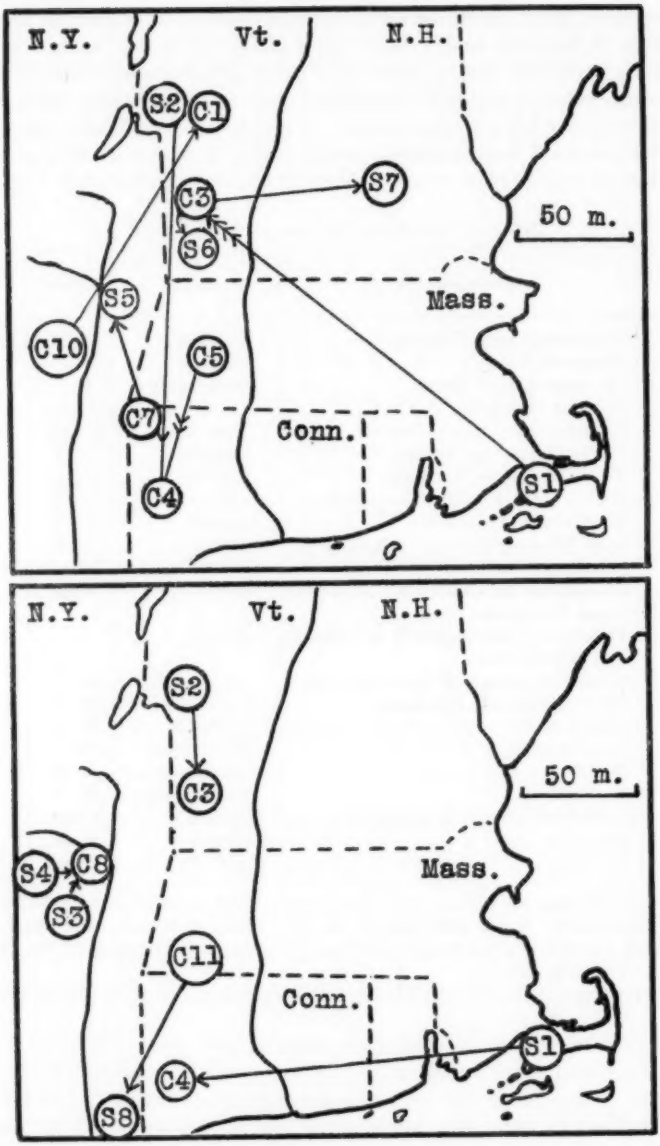
COLONY NO.	LOCATION AND TOWN	COUNTY	STATE	APPROXIMATE POPULATION OF COLONY
C-1	Nickwacket cave, Brandon[1]	Rutland	Vt.	300
C-2	Plymouth Union	Windsor	Vt.	75
C-3	Mt. Aeolus, East Dorset	Bennington	Vt.	500
C-4	Roxbury iron mine, Roxbury	Litchfield	Conn.	1000
C-5	Chester Emery mines, Chester	Hampden	Mass.	1000
C-6	Indian Oven cave, Ancram	Columbia	N. Y.	200
C-7	Twin Lakes cave, Salisbury	Litchfield	Conn.	100
C-8	Haile's cave, Thatcher State Park	Albany	N. Y.	300
C-9	Ward's cave, Clarksville	Albany	N. Y.	300
C-10	Near Pumping Station, S. Bethlehem	Albany	N. Y.	200
C-11	"Konkapot cat hole," Sheffield	Berkshire	Mass.	5
S-1	3 buildings at Hatchville, Mashpee, and Poponesset Neck	Barnstable	Mass.	500
S-2	Vicinity of Lake Bomoseen and village of Hubbardton	Rutland	Vt.	800
S-3	Houses in village of Rensselaerville	Albany	N. Y.	800
S-4	Old stone church, Schoharie	Schoharie	N. Y.	200
S-5	Rider's Mills	Columbia	N. Y.	*
S-6	Lake Shaftsbury	Bennington	Vt.	*
S-7	Henniker	Merrimack	N. H.	*
S-8	Katonah	Westchester	N. Y.	*
S-9	Lake Warmamaug, Washington	Litchfield	Conn.	*
S-10	Brockton	Plymouth	Mass.	*
S-11	Westboro	Middlesex	Mass.	*

[1] Nickwacket cave was erroneously listed in my earlier paper (Griffin, 1940a) as in the town of Chittenden. It has also appeared in other papers as Brandon and Pittsford, Vt. Mr. Harold Trapido informs that it is actually in Brandon, very close to the Brandon-Pittsford-Chittenden corner.

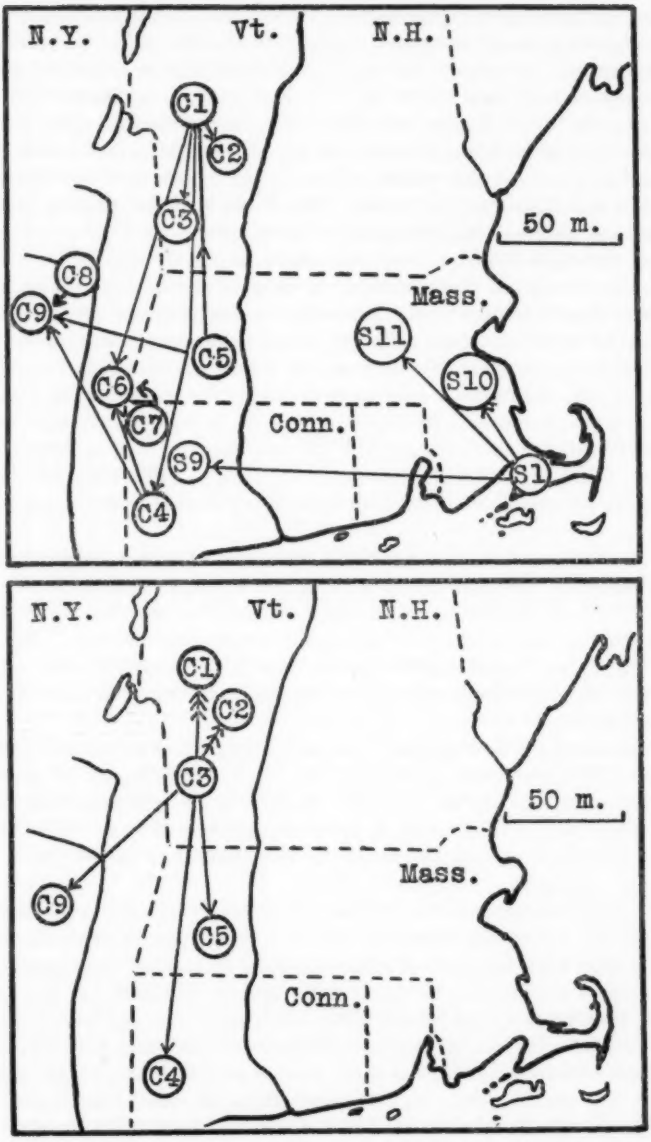
* Recovery reported to Fish and Wildlife Service; bats found singly in various situations.

returns may be from cave to summer colony or *vice versa*. These later-season returns may occur after a single migratory season and thus be records of a single migration, or more than one migratory season may have elapsed. In the latter case one does not know how much of the journey between cave and summer colony has occurred during a single migration.

Table 1 shows the details of the foreign returns secured too late to include in an earlier paper (Griffin, 1940a). All foreign returns, regardless of date, are mapped in figures 1 to 4, which show the points of banding and subsequent re-



FIGS. 1 (upper) and 2 (lower). Foreign returns of banded bats. Arrows indicate direction of flight, number of arrowheads shows number of bats retaken. C = cave, and S = summer colony. Fig. 1 shows same-season returns and later season returns where only one migration had occurred between banding and recovery. Fig. 2 shows later season returns after two or more migratory seasons had passed.



FIGS. 3 (upper) and 4 (lower). Foreign returns of banded bats (same symbols as figs. 1 and 2). Fig. 3 shows later season foreign returns from cave to cave or summer colony to summer colony. Fig. 4 shows later season cave-to-cave returns of bats banded at one cave near East Dorset, Vt.

capture. Most of these foreign returns were of *M. l. lucifugus*, the only species, except *Eptesicus*, that was banded at summer colonies. The conventions used on the maps are as follows: the direction of each flight is shown by an arrow. The colony at both ends of the flight is designated by a number such as C-2 or S-7, where "C" indicates cave and "S" summer colony. The number of bats recovered after flying between the two designated points is indicated by the number of arrowheads shown. Thus in fig. 1 four bats flew from S-1 to C-3, while one flew from C-7 to S-5. See Table 2 for local name, geographic location, and approximate population of each colony.

All of the same-season returns are shown in fig. 1, and it is interesting to note they were all movements from cave to cave. Fig. 1 also includes those later-season returns where bats were retaken after a *single* spring or fall migration to a different type of colony (cave to summer colony or *vice versa*). The interesting point about the same-season returns shown in fig. 1 is that there were three long flights from cave to cave during the winter. The flight from C-5 to C-4 of one *Myotis l. lucifugus* and one *M. keenii septentrionalis* occurred between February and April, and the 120 mile flight of a *M. l. lucifugus* from C-10 to C-1 took place between November and April. Folk (1940) has discussed shifts in the population of a bat cave which also indicated winter travels such as these.

The remaining returns shown in fig. 1 are instances of one season's migration over considerable distances between caves and summer colonies (all *M. l. lucifugus*). They are too few to give a complete picture of this migration, but they do show that it may be short or long and in almost any direction. Eisentraut (1936) found that *Myotis myotis* in caves near Berlin moved for the most part in a northernly direction in spring, showing less scattering than these New England cave bats.

Additional cases where the bats had moved from cave to summer colony or *vice versa*, but where two or more migratory seasons had elapsed between banding and recovery are shown in fig. 2. Some of these bats may thus have required more than one migration to cover the distances shown. All of these recoveries were *M. l. lucifugus*, except the one from C-11 to S-8 which was a *Pipistrellus subflavus*.

The later-season returns where the bats were both banded and retaken at the same type of colony are shown in fig. 3. These returns demonstrate that bats may shift from one cave or summer colony to another from year to year, even though the two may be many miles apart. It should be pointed out, however, that for every bat retaken after a shift from one cave to another about 100 were recovered in later winters at the same cave where they had been banded. A few bats were recovered at the same cave as long as 10 years after they were banded. The resulting data on longevity will be discussed elsewhere.

One bat (37-60205) flew from C-1 to C-4 between April and November of the same year, and then returned during the course of the next two years to C-1 (see Table 1).

Quite a different type of behavior from that characteristic of the other bat

colonies was observed at cave No. C-3 (East Dorset, Vt.). There was always a large population in the fall, but sub-freezing temperatures occurred during mid-winter in the main chamber where the bats preferred to roost. A large entrance and good air circulation caused the formation of huge icicles from seepage water on the walls, roof and floor of the cave, and the bat population was reduced to 25-50 by death and emigration from a normal fall population of 500-800. Few local returns were secured at this cave, even in subsequent autumns when the population was again high, but several foreign returns were retaken at other caves. So many, in fact, that it is most convenient to present them on a separate map, fig. 4. All were cave-to-cave later-season returns, and they were scattered throughout the area in which bat caves were visited. These returns suggest that bats are not infallible in their choice of winter quarters, and that winter flights not only do occur frequently, as shown by the returns in fig. 1 and by the work of Folk (*op. cit.*), but also may be necessary for survival, as in the case of the bats at East Dorset.

DISCUSSION

In view of the number of bats banded within the area of this study, both in caves and summer colonies, and the marked tendency for the bats of a colony to remain together (Griffin, 1940b), it is somewhat surprising that more foreign returns were not secured. The data obtained do not satisfactorily indicate either the summer range of the bats banded in caves or the winter quarters of those marked at summer colonies. Three possible explanations suggest themselves:

(1) *The coverage may have been too thin to sample more than an insignificant fraction of the caves or summer colonies.* This was probably true for summer colonies, but caves are scarce in this region, and the diminishing returns from a five year search for bat caves suggest that the majority of the large hibernation colonies in the area were found. Furthermore, each sizeable winter colony was worked sufficiently that the majority of the bats in it were banded. I could not find evidence of a hibernating population for the whole of New England and eastern New York that approached the most conservative estimate of the summer population of southern New England alone.

(2) *The bats may migrate entirely outside of the area studied.* In this case perhaps the bats banded in caves traveled to Maine or eastern Canada where no summer colony banding was attempted, while those banded at New England summer colonies might have flown west or southwest to New York, Ontario, New Jersey or Pennsylvania. It was the search for evidence concerning this hypothesis that led to banding activities in eastern New York where there are several relatively large caves. But the population found in these caves was no larger than the estimated summer population of the area. Furthermore, Hitchcock (1940), Hitchcock and Reynolds (1942), Mohr (1939), and Trapido have searched the caves of Ontario, New Jersey and Pennsylvania without recovering any bats banded in New England, although of course, travels of bats between these areas may be disclosed by further marking studies.

(3) *There remains a speculative possibility that these bats may use other places than caves for hibernation, at least in areas where caves are lacking.* Certainly the summer colonies in buildings are deserted by fall and most of them are not artificially heated sufficiently to protect the bats from freezing in mid-winter. Bats would probably be protected from freezing by small deep crevices in rocks such as those used by snakes, or even by woodchuck burrows; but there are no records for this region of any having been taken from such places during hibernation. *Eptesicus* hibernates in heated buildings, but this habit seems to be rare in *Myotis* and *Pipistrellus*. I have found *M. keenii septentrionalis* in December in a dry well at Barnstable, Massachusetts, and I have one or two reliable reports of small bats hibernating in cellars. The habits of bats are too little known to dismiss the possibility that in caveless areas they may habitually hibernate in unsuspected retreats. Perhaps this possibility may add zest to the future field work that is necessary before the life histories of cave bats can be satisfactorily understood.

SUMMARY

Fourteen long distance recoveries (10 to 156 miles) of banded cave bats are described in detail to supplment the 25 reported earlier (Griffin, 1940a).

The migration from cave to summer colony may be as short as five to ten miles or at least as long as 168 miles, and it may be in almost any direction.

Flights as long as 125 miles from one cave to another occurred during the winter months. There were also a few recoveries of bats that had moved from one summer colony to another; but the great majority of returns was retaken at the original place of banding.

At one cave a sizeable population was always found in late fall, but sub-freezing temperatures inside this large-mouthed cave forced hundreds of bats to leave during the winter. An unusually large proportion of the bats of this transient fall population was recovered during later winters in other caves.

The summer population in New England seems to be much larger than any hibernation colonies in caves that have been found in this general area. Migration of this summer population to the south and west has not been demonstrated despite considerable search for banded bats by other bat banders in New York, New Jersey, Pennsylvania and Ontario. The possibility suggests itself that many bats may hibernate in other retreats than the relatively large caves where they are generally studied.

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The Biological Laboratories, Harvard University, Cambridge, Massachusetts.

NOTES ON BREEDING BEHAVIOR, PREGNANCY, AND PARTURITION IN SOME VESPERTILIONID BATS OF THE EASTERN UNITED STATES

BY WILLIAM A. WIMSATT

This paper presents observations on copulation and parturition made in the course of a study of the female reproductive cycle and early embryonic development of *Myotis lucifugus lucifugus*. Copulation and parturition were witnessed a number of times, and since there are so few published accounts of these phenomena in bats we regard the present observations in *Myotis* as worthy of being recorded. In addition, some data on pregnancy in *Myotis lucifugus*, *Pipistrellus subflavus*, *Eptesicus fuscus*, and *Lasionycteris noctivagans* will be presented.

A brief summary of the reproductive cycle of vespertilionid bats will provide a background for better appreciation of the observations to follow. Previous studies have revealed that the hibernating bats of the eastern United States mate during the fall (September and October). The spermatozoa are stored in the uterus during the winter, and the stored sperm may fertilize ova released from the ovaries in the spring (Gates, 1936; Folk, 1940; Wimsatt, 1942; Wimsatt, 1944a). During hibernation the female bat is in a state of sub-estrus (Guthrie and Jeffers, 1938b; Reeder, 1939) and the enlarged Graafian follicles that are destined to rupture in the spring are visible in the ovaries as early as the beginning of hibernation in the fall (Guthrie, 1933; Wimsatt, 1944b). Ovulation is spontaneous and occurs late in April or early in May. Spermatogenesis occurs only during the summer months and the testes and the seminiferous tubules undergo involution and become quiescent during the winter. Yet, the male accessory glands remain functional throughout the winter, and the cauda epididymidis is filled by a great mass of mature spermatozoa which is retained until the end of hibernation in the spring (Miller, 1939).

During hibernation, therefore, the genital tracts of both male and female bats are in a semi-active state and, under certain conditions, when the animals are aroused, they have been observed to copulate. Parturition takes place near the end of June or during the first half of July. (This statement applies only in the vicinity of Ithaca, New York. The dates of parturition vary somewhat in other localities.)

OBSERVATIONS

Mating behavior.—Hibernating bats (*Myotis lucifugus*) were observed mating during the winter months in Aitkin cave, Mifflin County, Pennsylvania. The bats were invariably quiescent when the cave was first entered, but numbers of them were always awakened by the disturbance created by our lights, movements, and conversation. After an hour or two, if the disturbance was prolonged, pairs of bats were occasionally seen copulating. Mating pairs were ordinarily found in the larger clusters or under less crowded circumstances at the edges of clusters, but they were seldom found far removed from a cluster. Although Aitkin cave has a population of between three and five thousand bats, no more than six copulations were witnessed on any one trip, even though our observations lasted seven or more hours. On numerous trips none at all was seen. The infrequent matings were not due to the significant preponderance of one sex, since among 698 specimens taken at random for banding purposes on three different trips there were 377 males and 321 females. Counts of several individual clusters in which copulating pairs were observed revealed that males and females were about evenly represented in each. Griffin (1940) witnessed copulation only once during numerous trips to caves in New England, but H. Trapido (personal communication) observed copulation a number of times among the hibernating bats in an abandoned mine in New Jersey. Murphy and Nichols (1913) state that the red bat (*Lasiurus borealis*) copulates while in flight.

In the matings observed by us in *Myotis lucifugus* the male always mounted the female in the position of coitus *a posteriori*. The following sequence of behavior took place. The male grasped with his teeth the hair of the female at the base of the skull and pulled her head far back, usually at a right angle to her body. The male strengthened his grip by using his thumbs to hold her body in place, and then pushed his hindquarters backward and downward around the rump of the female, bringing his protruded penis beneath her interfemoral membrane. By a forward movement at this moment the penis was brought close to the vaginal orifice.

During this preliminary phase of copulation the penis became erect, and the glans became bulbous and noticeably hyperaemic. When copulating pairs were removed from the wall of the cave for closer inspection, they would remain in the copulatory embrace for several moments before showing signs of disengaging. In one pair found *in coitu* both male and female were dormant. It is of further interest that dormant males have occasionally been found with a full erection. Some of these males were not near females when collected. In one case a male was pulled apart from a female, and at the moment the penis was released from the vagina a large drop of a cloudy fluid was ejaculated from the penis with considerable force. It was not feasible at the time to examine this discharge for the presence of spermatozoa.

A single copulation was observed in *Myotis subulatus leibii*; the procedure was in every way similar to that observed in *Myotis lucifugus*. This mating was consummated under conditions favorable for observation, and details of the

act were seen which could not be distinguished in *Myotis lucifugus*. The pair had been collected while attempting to copulate and had been placed in a small field cage of quarter inch wire mesh. Shortly thereafter, a second female was placed in the same container. About an hour later, in open air and daylight (temp. 47°F.) the male again manifested an interest in the female, despite the fact that the cage was being held in the hands of the observer. The male paid no attention to the second female placed in the cage and at times he crawled right over her while pursuing the female with which he had previously attempted to copulate. He finally succeeded in grasping the first female with his teeth by the nape of the neck and, holding her with his thumbs as well, he mated with her. Since the underside of the female was against the wire of the cage, the details of copulation could be observed. After the male had mounted the female, the erect penis could be seen probing first the anus and then the vaginal orifice. With some effort it finally gained access to the vagina. The penis appeared to move vigorously and relatively independently, so far as could be observed, of any essential movements of the hindquarters of the animal. With the penis in the vagina, both animals remained quiet except for a quivering of the hindquarters of the female reminiscent of very rapid breathing. Unfortunately, copulation was not carried to completion because sudden accidental movements of the cage disturbed the animals and they ceased their copulatory activity. Nevertheless, it seemed definite from the observations on both *Myotis subulatus leibii* and *Myotis lucifugus* that the male initiates copulation, whereas the rôle of the female is passive. The presence of the interfemoral membrane of the female did not seem to embarrass the male as might be expected in the posterior approach, since the free movements of the penis carried this organ around and beneath the membrane.

Sex ratios of bats on the summer range.—Pregnant bats of several species were examined each spring from 1940 to 1943 inclusive. These were either shot while feeding at dusk or removed directly from two colonies in old dwellings near Ithaca, New York. The species principally collected and described in this section are *Myotis lucifugus*, *Pipistrellus subflavus*, and *Eptesicus fuscus*. Only *Myotis* was found abundantly in the summer roosts. Groups of two to four pipistrelles were occasionally found in old houses, but not in the same habitations with *Myotis*. The specimens of *Eptesicus* were taken from caves in fall and winter and maintained in artificial hibernation until spring. A few observations on *Lasionycteris noctivagans* are also included.

During the first year of continuous collecting (spring, 1941), it became obvious that the number of females shot far exceeded the number of males so obtained. This was particularly true during May and June, but later in the summer (August) males were more frequently taken. Between April 30 and May 13, 1941, only one out of thirty-eight *Myotis lucifugus* was a male. From May 14 to 30, thirteen males were shot in contrast to fifty-four females, whereas one of eleven bats shot between June 2 and 5 was a male. In 1942, during the first two weeks of May, two male bats were taken in contrast to seventeen females, and the figures were four males to twenty-five females during the last

two weeks. From June 1 to 8 fourteen bats were taken and only four were males. Of eleven *Myotis lucifugus* shot between May 6 and 20, 1943, four were males.

Twenty-six *Pipistrellus subflavus* were shot during May from 1940 to 1943 inclusive and only one was a male. Twenty-two female *Lasionycteris noctivagans* were collected during May, from 1940 to 1942 inclusive, with not a single male among them. Although the sex ratios in *Pipistrellus* and *Lasionycteris* resemble those in *Myotis lucifugus*, not enough of the former species were taken to warrant definite conclusions concerning the summer sex ratio. All of these bats were shot in Ithaca, New York, at the Cornell University rifle range on Fall creek. It is yet to be determined whether these observations made on a limited area have a more general application.

During the late springs of 1941, 1942, and 1943 many *Myotis lucifugus* were removed from two large summer roosts in old dwellings, one at Cincinnatus, and the other at Malloryville, near Ithaca, New York. Table 1 presents the

TABLE 1.—*Sex ratio of bats (Myotis lucifugus) collected from two summer colonies (1941 to 1943)*

CINCINNATUS, NEW YORK			MALLORYVILLE, NEW YORK		
Date collected	Male	Female	Date collected	Male	Female
May 16, 1941	0	20	May 3, 1942	0	45
May 18, 1941	0	10	May 10, 1942	0	16
May 24, 1941	0	28	May 2, 1943	0	40
			May 9, 1943	0	17
			May 23, 1943	2	24
			June 29, 1943	4	46
Totals	0	58		6	188

date, number, and sex of the bats collected in these roosts. It should be noted that no males were found in the Cincinnatus colony, while in the colony at Malloryville only six males were found over a period of three years. These observations agree with those of Griffin (1940), who observed that the summer colonies in New England, particularly in early summer, contain females almost exclusively.

Griffin (*op. cit.*) reports that 72.5 percent of 3703 hibernating *Myotis lucifugus* taken from ten caves were males and he asserts that Mohr found a similar unbalanced ratio in Pennsylvania bat colonies. In the present study a total of 698 *Myotis lucifugus* were removed from Aitkin cave on three successive trips, and just over 54 percent of these were males. Inasmuch as significant differences exist in the number of males and females found in summer and winter, it is evident that any sex ratio based only upon counts made in summer would be inaccurate. The counts made in the caves during the winter would more likely be representative, since the relatively few caves suitable for hibernation attract bats from distant surrounding areas. Griffin (*op. cit.*) believes that there is a

1:1 sex ratio in *Myotis lucifugus* at birth. He bases his estimate on counts made upon 890 immature animals banded in summer colonies. At the present time, however, the numbers counted in many different caves are not sufficient to justify definite conclusions concerning the true sex ratio of adults. The presence of an overwhelming majority of females in the roosts during early summer might indicate *a priori* that most males either live isolated outside the colonies or congregate in special roosts elsewhere. I have never found a colony of males nor have I seen reference to one in the literature and hence the presumption is that the males remain isolated during the summer. Being more generally distributed, they are less frequently encountered than females within the vicinity of a colony of the latter.

Pregnancy.—(1) *Fertility:* It is well known that there is a variation in the number of young produced in the different species of bats, and in some cases even between different species in the same genus. This is true among the several forms inhabiting the United States. It is of interest to determine whether the variation in the number of young born is due to some inherent genetic factor or other factor which regulates the number of ova released from the ovary at ovulation, or whether the internal environment of the uterus limits the number of ova carried to term to a fraction of the ova released at ovulation.

Observations on several species indicate that except in *Myotis lucifugus* there is ordinarily no correlation between the number of ova released and the number of offspring produced. In *Myotis lucifugus* only a single young is born and only one ovum is ordinarily shed. There are records of two young (Gates, 1936) in this species, and in my own series three such cases have come to light. In one of these two four-cell cleaving ova were removed from the right oviduct, while the other two specimens each possessed two fetuses far along in development. It is probable, however, that not over 1 percent of all pregnancies in *Myotis lucifugus* involves more than a single egg. Only one corpus luteum was found in 185 specimens that contained a single embryo, and in 95 other females examined during hibernation only a single Graafian follicle was present in the ovaries. These findings are in keeping with the observation that the short uterine cornua in *Myotis lucifugus* are unequally developed, the right being larger than the left, and that the uterus can therefore accommodate comfortably only the single ovum which is customarily released. The functioning of the ovaries does not follow the pattern, however, since the ova come as frequently from the left ovary as from the right (Guthrie and Jeffers, 1938c; Wimsatt, 1944b).

Although in *Myotis lucifugus* no more ova are customarily shed from the ovary than can be carried successfully to term, in *Pipistrellus subflavus* and *Eptesicus fuscus* the ova shed outnumber the embryos that survive to parturition. Guthrie (1933) made the following counts of Graafian follicles or tubal eggs in seventy female pipistrelles collected in Missouri. Twenty-four possessed four large follicles or tubal eggs, 17 had five, 15 had three, 9 had six, 2 had seven, and 1 each had two, one, and no Graafian follicles or tubal eggs. She presents no observations on the fate of these ova, but suggests that some may not complete

gestation. Hahn (1908) found a gravid pipistrelle which contained three 2 mm embryos. Bailey (1931) reports two as the usual number of young in *Pipistrellus hesperus* and Allen (1940) states also that members of the genus *Pipistrellus* seem regularly to have two offspring. Deanesly and Warwick (1939) found that only a single young is ordinarily produced by *P. pipistrellus* in England, whereas on the continent two are frequent if not usual (Allen, 1940). In *Eptesicus* similar conditions obtain. Guthrie (1933) examined two females, one with six and the other with four tubal ova. This author describes a female brought to her on June 9 with two new-born young attached. Bailey (1931) gives the number of young as one for this species, a statement which Allen (1940) also makes. Griffin (1940) believes that two is the customary number of young produced by *Eptesicus* in New England. The only bat definitely known to have more than two young at birth is the red bat (*Lasiurus borealis*), in which females with three and four young have not infrequently been found (Lyon, 1903).

These data indicate that one or two offspring are the rule in *Pipistrellus* and *Eptesicus*, but that usually a greater number of ova are shed at ovulation. Of 41 female *Eptesicus fuscus* examined in the present study, 32 were pregnant. The latter possessed 129 corpora lutea and 112 fertilized ova ranging in development from ova of two blastomeres to implanted blastocysts. The largest number of corpora found in a single bat was seven, the smallest, three. The remaining nine females were examined before ovulation had occurred and 45 enlarged Graafian follicles were found in the ovaries. Thus, 41 female *Eptesicus* possessed a total of 174 corpora lutea or maturing Graafian follicles, or an average of 4.24 per female. This is considerably in excess of the number of young ordinarily produced. Twenty-eight females of *Pipistrellus subflavus* were likewise examined. Ten specimens each bore two very advanced embryos, but the ovaries were unfortunately not examined for corpora lutea. Fourteen pregnant specimens whose reproductive organs were sectioned serially possessed a total of 49 corpora lutea and 45 fertilized ova that ranged in development from the four-cell stage to near term fetuses. Three hibernating specimens that were examined before ovulation had occurred possessed three, four, and five maturing Graafian follicles respectively. In another specimen embedded for sectioning, the ovaries contained at least three corpora lutea.

In view of the obvious discrepancy that exists between the number of ova shed and young produced, it is clear that in *Pipistrellus* and *Eptesicus* the number of young is not limited by a factor operating in the ovary to reduce the number of ova released, but by something in the uterine environment that determines the number of ova that can be brought to term. The uterus of *Pipistrellus* and *Eptesicus* is bilaterally symmetrical (in contrast to the asymmetrical uterus of *Myotis lucifugus*), a condition that in itself would permit the successful carrying of more than one fetus.

Since in *Pipistrellus* and *Eptesicus* more ova are usually shed than are able to survive until parturition, it is obvious that the remainder must degenerate. At what stage of their development does this occur? What factors are responsible? The answer to the first question was easily determined by examination

of serial sections of the female genital tracts. Apparently most ova shed succeed in implanting. It is only later, when the continued enlargement of the embryos within the relatively narrow confines of the uterus produces overcrowding, that the embryos less advantageously situated in the uterine cornua begin to be eliminated. Resorption of ova probably occurs in most females of *Eptesicus* and *Pipistrellus* during each gestation period.

Pipistrellus is of further interest for in the specimens examined in this study a definite pattern of resorption is suggested. Three or four ova are shed and usually implant no more than two to a horn. The ova grow equally for a time, but soon the pair implanted medially (adjacent to the corpus uteri) lag behind in development and are resorbed. The general rule in *Pipistrellus* would seem to be that in a cornu containing two embryos, the embryo situated nearest the corpus uteri is most likely to be lost. The observations indicate that the portion of the horn at some distance from the corpus is best fitted for the successful implantation and maintenance of an ovum. Although resorption may be initiated by overcrowding, the fact that embryos in a particular location near the corpus are almost invariably the ones that are eliminated appears to indicate that a gradient of conditions that are essential for embryonic development exists within the uterus.

(2) *The length of gestation in Myotis lucifugus:* Rollinat and Trouessart (1896) found that pregnancy lasted more than 40 days in *Myotis*, while Deanesly and Warwick (1939) determined that gestation continues for 44 days or longer in the small European bat *Pipistrellus pipistrellus*. Sherman (1937) states that gestation lasts between 11 and 12 weeks in the Florida free-tailed bat *Tadarida cynocephala* (Molossidae). As far as I have been able to determine, the free-tailed bat is the only American species in which the length of pregnancy is known. It is interesting to note that pregnancy in this molossid is longer by several weeks than in the vespertilionid bats for which estimates are available.

Observations on pregnancy in a large series of bats, collected under natural conditions during a period of three years, have revealed that parturition in *Myotis lucifugus* occurs near the end of June or during early July in the vicinity of Ithaca, New York. There may be some variation from one year to another, depending upon variations in climatic conditions, but the difference is probably not more than a week or two. In the summer of 1940, 12 female bats of this species were shot at the same locality between July 1 and 9 inclusive. Of these, 10 carried fetuses near term, while 2 possessed puerperal uteri. Bats were not shot at the beginning of gestation in 1940, so it is not known approximately when ovulation took place. In the spring and summer of 1943, however, bats were taken as they arrived at a summer colony and again when parturition had begun within the colony. From these data it is possible to determine the approximate duration of pregnancy.

Of 40 females collected from the colony on May 2 and killed between May 2 and 4, 6 possessed newly fertilized tubal eggs, 4 had tubal ova of two cells, 1 had a tubal ovum of three cells, 2 had tubal ova of four cells, 2 had uterine ova of seven cells, 8 had uterine ova in the morula stage, and the remaining 18,

of which the genital tract was preserved entire, possessed cleaving tubal and uterine eggs, none of which had begun to implant.

Seventeen females were taken from the colony on May 9, and 14 were killed on May 9 and 10. Four of these possessed tubal ova of four to six cells. Ten possessed uterine ova, of which six were in various stages of implantation and the other four were in the morula or free blastocyst stage. When these data are compared with the known rate of development in the earliest stages as determined by Guthrie and Jeffers (1938a) following experimentally induced ovulation, it appears probable that follicular rupture had occurred, for the most part, between April 28 and May 10. These authors induced ovulation in 10 specimens of *Myotis lucifugus* during February by the injection of hypophyseal extract on each of three successive days. Three uninjected controls did not ovulate. A four-cell tubal ovum was found two days after the last injection, all eggs were uterine after five days, and free blastocysts were found on the tenth day.

Of 31 females collected from the colony on June 29, 13 had recently borne young, and 18 were obviously near parturition. Of the latter, nine produced young on the evening of June 30. On June 29, a further large number of females of the same colony were examined; one-third to one-half of them were found to have already borne offspring, and most of the remainder were within a few days of doing so. The majority of the young bats were only a few days old and weighed less than three grams (the adults average six to eight grams and the young are 1.5 to 1.9 grams at birth). Newborn individuals with umbilical cords still attached were found, as were also several half-grown individuals. It may be assumed, therefore, that most of the bats in the colony brought forth their young between June 22 and July 5. Since the majority of bats had ovulated between April 28 and May 10, the period of gestation in *Myotis lucifugus* is probably between 50 and 60 days in length.

(3) *Parturition in Myotis lucifugus:* Eighteen females near term were removed from the Malloryville colony on June 29 and placed for observation in a large cage out of doors. During the afternoon and evening of June 30 nine of them gave birth to young and the process was watched in several instances. In three cases the young were born dead, due perhaps to rough handling of the parents and a sudden drop in temperature on June 29 and 30.

As parturition begins, the female hangs head upward, just the reverse of the normal resting position, and the tail and interfemoral membrane are cupped ventrally to form a depression in which the emerging fetus is cradled. In every case the fetus emerged from the vagina breech first, the head being the last portion to come free. The tail and interfemoral membrane appear first, followed by one of the hind legs and the rump. As more and more of the fetus appears, the parent licks it, thereby helping to free the wings and legs which are stuck tightly to the body. In the last stages of birth, when only its head is engaged in the vagina, the young one frequently becomes quite active and is even seen to push and pull against the mother with the wings and hind feet in an effort to free the head. Once free, the young one is again carefully licked

by its parent. For a time the youngster remains attached to the mother by means of the umbilical cord connected with the placenta within the tract, but as the placenta slowly approaches the vulva the female chews and usually severs the cord close to the placenta. The cord dries in a few minutes and after shrivelling up eventually breaks off at the umbilicus. During delivery the fetus is wet from the amniotic fluid, and apparently it is this that the mother cleans off. The amnion and chorion are folded back along the cord and over the placenta and come free with the latter. The young are born with their eyes closed. The wings, ears, legs, tail, and interfemoral membrane are nearly black, but the trunk and head are flesh-colored and covered by fine silky hair. As previously stated, the newborn young weigh from 1.5 to 1.9 grams (based on three fetuses weighed immediately after parturition), a truly remarkable weight when one considers that the mothers weigh only seven to nine grams.

Although the mother frequently chews through the umbilical cord as the placenta is being delivered, this is not invariably true, since newborn young have been observed with desiccated cord and placenta still attached to them. A number of fresh placentae were found on the floor of the loft in which the colony was located, and in only one of the nine parturitions observed in the cage did the mother eat the afterbirth. Hence, although most observers of parturition in bats state that the placenta is consumed by the female, this does not seem to be the rule in *Myotis lucifugus*.

The time required for parturition varies, but normally it is completed in 15–30 minutes. In one case in which the fetus was born dead, parturition lasted 1½ hours. In another case in which the fetus was born dead, parturition lasted nearly 4 hours and the placenta did not come free for 5 hours longer. This was a very abnormal birth. In one normal birth the hindquarters of the fetus were found protruding from the vagina, and the shoulders and head came free in 5 minutes. In all other cases the young were born in just over 15 minutes.

The frequency of labor contractions was checked in one specimen at a time when the fetus was emerging most rapidly. There was a series of fairly rapid muscular paroxysms that were separated by only a few seconds, followed by a rest period of variable length before the next series of contractions began. Each series of contractions lasted only one to two seconds and consisted of three to six violent expulsive constrictions. Nine successive rest periods between series of labor contractions varied in length as follows: 35 seconds, 15 seconds, 15 seconds, 90 seconds, 15 seconds, 15 seconds, 195 seconds, 15 seconds, and 10 seconds. During this sequence the rump of the fetus and its body up to the shoulders emerged.

The parturition of *Myotis lucifugus* appears to correspond with the process in the few other vespertilionid bats that have been studied. Daniell (1834) describes a head presentation in *Nyctalus noctula*, but this is the only record of its type published, and more recent observers have not witnessed a similar birth. The normal breech presentation of bats seems to be unique among mammals.

SUMMARY

Copulation was observed during the winter among hibernating bats (*Myotis lucifugus lucifugus* and *Myotis subulatus leibii*) in a Pennsylvania cave, and the process is described in detail.

A disproportionate sex ratio favoring the females was observed in bats shot on their summer feeding grounds. Collections made at two summer colonies revealed that these were almost exclusively made up of pregnant females. The possible significance of these observations is discussed.

Between species, variations in the number of young produced are attributed to one of two sets of factors: (a) factors operative within the ovary, which limit the number of ova shed (*Myotis lucifugus*), or (b) factors in the uterine environment which prevent the successful carrying to term of all of the ova shed at ovulation (*Pipistrellus subflavus* and *Eptesicus fuscus*). *Myotis lucifugus* normally sheds but a single ovum, and its uterus has become structurally modified to facilitate implantation and growth of only one ovum. *Pipistrellus subflavus* normally bears two young and *Eptesicus fuscus* may have one or two, but in both of these species anywhere from two to seven ova are usually shed. Most ova implant, but those in excess of the number of young characteristically produced are eventually resorbed.

The length of gestation in *Myotis lucifugus* was estimated to be between 50 and 60 days.

The details of parturition in *Myotis lucifugus* were observed in nine females that brought forth young the day following their removal from a summer colony. The important features of the process are described.

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Laboratory of Histology and Embryology, Cornell University, Ithaca, New York.

NOTES ON COYOTE FOOD HABITS IN MONTANA AND BRITISH COLUMBIA

BY OLAUS J. MURIE

In the course of other field studies there have been opportunities from time to time to assemble considerable information on the basic food habits of the coyote. The results of some of these studies are here presented, not as completed field projects but merely as a slight contribution.

During the month of June 1934, and again in June 1935, I was assigned to the waterfowl investigations in British Columbia; the month of July 1934 was spent on an elk range study on the Lewis and Clark and the Flathead National Forests in Montana; and in August 1935 I was engaged in a game range survey along the Missouri River, above Fort Peck, Montana. On all of these investigations coyote droppings were collected as opportunities were offered and other pertinent information was recorded. Although these activities were entirely incidental to the main work, the accumulated material is sufficient to be worthy of record.

BRITISH COLUMBIA

The area in which coyote data were obtained in British Columbia was chiefly tributary to the Cariboo Road, in the interior, from 111-mile Creek northward to

TABLE 1.—*Food items in 311 coyote scats, Interior British Columbia*

	NON-CARRION NUMBER	CARRION NUMBER OF OCCURRENCES	PERCENTAGE
Mammals			
Snowshoe rabbit, *Lepus a. macfarlani*	271		69.39
Domestic cow		17	4.35
Mule deer, *Odocoileus h. hemionus*	14	3	4.35
Mule deer fawn, *Odocoileus h. hemionus*	1		.25
Field mouse, *Microtus sp*	8		2.05
Moose, *Alces sp*		6	1.53
Horse		6	1.53
Red squirrel, *Sciurus sp*	4		1.03
Woodrat, *Neotoma sp*	4		1.03
Muskrat, *Ondatra zibethica spatulata*	3		.76
Porcupine, *Erethizon epixanthum*	3		.76
Domestic sheep	3		.76
Marmot, *Marmota monax subsp*	1		.25
Deer mouse, *Peromyscus sp*	1		.25
Total	313	32	88.2
Birds			
Ducks, sp	12		3.07
Duck eggs	1		.25
Small bird	1		.25
Small bird egg	2		.51
Grouse sp	2		.51
Grouse eggs	2		.51
Spruce grouse, *Canachites sp*	3		.76
Ruffed grouse, *Bonasa umbellus umbelloides*	1		.25
Eggs (small duck or grouse)	2		.51
Large bird sp	2		.51
Common loon, *Gavia immer*	1		.25
Total	29		7.4
Miscellaneous			
Fish sp	2		.51
Grasshoppers	2		.51
Beetles	2		.51
Pieces of large bone	2		.51
Grass	6		1.53
Rose seeds	1		.25
Miscellaneous rubbish	1		.25
Piece of thin wire 6″ long	1		.25
Total	17		4.4
Summary			
Total number of mammal items	13	32	88.2
Total number bird items	29		7.4
Total other items	17		4.4
Total all classes	359	32	100

Prince George, thence west to Vanderhoof and Fraser Lake. Other material was obtained in the Chilcotin country west of Williams Lake. A total of 311 droppings were collected and analyzed.

The food items included in this lot are listed in Table 1, the percentages being based, necessarily, on number of individuals rather than on volumes. In the case of insects and vegetation, however, number of times of occurrence is used, rather than the actual number of individuals. Furthermore, in the case of large animals, such as horse, cow, moose and deer, a somewhat similar interpretation should be kept in mind. For instance, it was known that many of the droppings containing remains of domestic cattle came from a single dead cow near Seventymile House. Probably there were similar duplications in the case of other large animals, such as moose and deer. These considerations apply also to the tables for localities in Montana. Known carrion is listed in a separate column. In the case of rabbits, as well as most other items of smaller size, the number of animals listed actually coincides with the number of droppings in which they occur. In the following tables, therefore, with only a few exceptions, these two designations would be synonymous.

For an understanding of the significance of these figures a discussion of the environment is needed. While the country in general is an excellent breeding ground for waterfowl, the nesting ducks are not as a rule concentrated. Some of the most favored lakes support a high duck population, but lakes are scattered widely and often there are only a relatively few nesting ducks at each pond, lake or slough. Furthermore, some species of ducks nested far from water, in an inconspicuous place, and could not readily be found by following the margin of any body of water. This situation may account for the small percentage of duck remains found in this lot of coyote droppings, less than 4 percent of all items.

While 115 coyote droppings were collected between Prince George and Endako, west of Vanderhoof, in places where nesting ducks and favorable duck environment are at a minimum for this region, the remaining 196 droppings were taken in the midst of the good waterfowl areas.

The outstanding feature of this particular study is the surprisingly high percentage of snowshoe rabbit in the diet, 69.39 percent for this one item, 271 out of 311 droppings containing rabbit remains wholly or in part.

It is believed that both winter and summer food was represented in this material, since some of the rabbits were in winter pelage, but the majority of the droppings doubtless represented the spring and summer.

SUN RIVER AND FLATHEAD RIVER, MONTANA

During July 1934, a collection of 286 coyote droppings was obtained and analyzed from the Sun River drainage of the Lewis and Clark National Forest and the headwaters of the South Fork of the Flathead River. Seventeen of these had been collected by Adolph Murie. Table 2 presents the food items represented.

In this lot of material two things stand out—the large percentage of snowshoe

rabbits and ground squirrels (totalling 59.18 percent of the whole), and the significant quantity of adult and young elk, 19.36 percent.

TABLE 2.—*Food items in 286 coyote scats, Sun River and Flathead River, Montana*

	NON-CARRION NUMBER	CARRION, NUMBER OF OCCURRENCES	PERCENTAGE
Mammals			
Snowshoe rabbit, *Lepus b. bairdii*	116		31.18
Columbian Ground Squirrel, *Citellus c. columbianus*	104		28
Elk, *Cervus c. nelsoni*, adult		43	11.56
Elk, *Cervus c. nelsoni*, calf	29		7.80
Cervid sp. (deer or elk young)	3		.8
Mule deer, *Odocoileus h. hemionus*	1		.27
Field mouse, *Microtus sp.*	23		6.18
Porcupine, *Erethizon epixanthum*	4		1.07
Deer mouse, *Peromyscus sp.*	4		1.07
Chipmunk, *Eutamias sp.*	3		.8
Jumping mouse, *Zapus sp.*	3		.8
Marmot, *Marmota f. nosophora*	3		.8
Mantled ground squirrel, *Callospermophilus sp.*	2		.54
Beaver, *Castor canadensis*	1		.27
Pocket gopher, *Thomomys sp.*	1		.27
Woodrat, *Neotoma sp.*	1		.27
Total	298	43	91.67
Birds			
Grouse sp.?	6		1.61
Blue grouse, *Dendragapus*	3		.8
Flicker, *Colaptes cafer*	2		.54
Sapsucker, *Sphyrapicus*	1		.27
Small bird, eggs	1		.27
Total	13		3.49
Miscellaneous			
Garter Snake	1		.27
Grasshoppers	5		1.34
Beetles	1		.27
Huckleberries	1		.27
Pieces of large bones	3		.8
Pieces of leather	1		.27
Grass	6		1.61
Total	18		4.84

With reference to the elk items, the situation is comparable to that prevailing in Jackson Hole where a detailed study has been made (Murie, 1935). In that instance it was concluded that although an unknown number of the elk calves consumed were coyote kills, the elk population was not seriously affected. The

adult elk represented in the present study were, of course, carrion. The head of Flathead River, where most of the material containing elk was obtained, was known to be a problem area where winter losses among elk and deer were heavy.

Birds were evidently seldom preyed upon in this area, the total of all species being 3.49 percent.

TABLE 3.—*Food items in 67 coyote scats, Missouri River, west of Fort Peck, Montana*

	NON-CARRION NUMBER	CARRION NUMBER OF OCCURRENCES	PERCENTAGE
Mammals			
Cottontail, *Sylvilagus nuttalli grangeri*	45		48.39
White-tailed jackrabbit, *Lepus t. campanius*	4		4.3
Deer mouse, *Peromyscus sp.*	1		1.07
Deer, *Odocoileus sp.*	1		1.07
Domestic cow		2	2.15
Horse		3	3.22
Total	51	5	60.22
Birds			
Small birds (including 1 flicker, 1 horned lark, 1 sparrow)	10		10.75
Large birds	2		2.15
Total	12		12.9
Other vertebrates			
Snakes (including 2 bullsnakes)	5		5.37
Total	5		5.37
Insects			
Grasshoppers	16		17.2
Beetles	1		1.07
Total	17		18.27
Vegetation			
Choke cherry, *Prunus melanocarpa*	2		2.15
Skunk brush, *Rhus trilobata*	1		1.07
Total	3		3.22

FORT PECK AREA, MONTANA

A more limited number of scats was collected along the breaks of the Missouri River, above Fort Peck, chiefly at Billarge and Big Dry Creeks. These are analyzed in Table 3.

The material in this case is meager, but it is sufficient to indicate once more the preponderance of rabbit in the diet, 48.39 percent cottontail and 4.3 per-

cent white-tailed jackrabbit, or a total of 52.69 percent. Out of 67 droppings collected, 49 contained rabbit wholly or in part.

In this instance there is a greater percentage of small birds, 10.75 percent. Grasshoppers were also prominent in the diet, some of the droppings consisting entirely of these insects. Incidentally, at the time of these collections grasshoppers were swarming in eastern Montana.

DISCUSSION

These data are not offered as a solution to any local economic problem, although they do have a basic bearing on such a study. In the first place, if such studies are to have economic importance, vastly more material should be available from a given locality, probably 1000 or more samples. Furthermore, the mere statement of a percentage of any item in the diet is no longer considered sufficient for economic evaluation. A comparatively scarce item in the diet may conceivably have an importance greater than the percentage figure indicates.

In a study recently published by Adolph Murie on the "Ecology of the Coyote in the Yellowstone" over 5,000 coyote droppings were analyzed, all taken in Yellowstone Park. Yet only 6 pages are devoted to discussion of these food items, in a bulletin of 206 pages. These data were only used as a base to start from and major effort was given to a study of the populations of the prey species, to determine what factor the coyote might be in each case. I believe it is conceded today that the ecological approach is the proper one.

Referring again to the data in the present study, it might be mentioned that in the Sun River-Flathead River region in Montana I did not learn of any important economic problem involving the coyote either with game or with livestock. In the Fort Peck region the presence or absence of any economic coyote problem was not known to me. The collection of material was only incidental to other duties.

In British Columbia there were some indications. In areas where flocks of domestic sheep were present, coyote depredations were reported. The meager findings of sheep remains in the droppings collected probably are not sufficient in themselves to evaluate the situation. Investigations on total sheep losses would have to be made. Also, areas covered included only the summer range of deer. For a complete picture it would be necessary to investigate their winter range in the breaks of the Fraser River.

With reference to waterfowl, however, some rumors to the effect that coyotes preyed extensively on ducks were not substantiated by these studies. Adolph Murie's (1940) studies in the Yellowstone and Richard Bond's (1939) studies in the Lava Beds National Monument are comparable to the study here reported and they found that coyote depredations on waterfowl were unimportant in those areas. Here again, one must admit that the present material is inadequate and that studies of the nesting ducks themselves should be made.

From another standpoint, however, data here reported have a definite value. From the standpoint of the naturalist they do indicate the normal food habit

pattern in each locality. In British Columbia the snowshoe rabbit is abundant and easily obtained and we find that it is the coyote's staple food. It is noteworthy that the snowshoe rabbit occurred in 271 droppings of a total of 311, practically 70 percent of all items. This is probably the highest percentage of rabbit so far recorded in the coyote's diet. If the volumetric system could have been used, it would have been still higher. We may correlate this high percentage with the well known abundance of snowshoe rabbits in the North and the relative scarcity of ground squirrels in the particular area here under consideration. We may take into account the relative ease with which rabbits are captured for they are a favorite prey in the north woods.

In the Sun River-Flathead River area of Montana the snowshoe rabbit again heads the list with 116 occurrences in 286 droppings, or 31.18 percent, but is closely followed by the abundant ground squirrel with 104, or 28 percent. In this instance the field mouse is noticeably present; only 23 were listed.

Again, in the breaks of the Missouric River cottontails were abundant and they, together with the less abundant white-tailed jackrabbit, made up 52.69 percent of the coyotes' diet.

These findings agree with those of C. C. Sperry (1941), in his valuable country-wide study of coyote stomachs, who found that "rabbits easily took first place in the diet," and that the average percentage was 33.25, reaching a high of 52 percent in May.

However, when we compare the present findings with those in the Yellowstone-Jackson Hole country the situation is different. Snowshoe rabbits are present, but they apparently do not reach the high population levels characteristic of more northern localities. On the other hand, field mice and pocket gophers are abundant and even marmots maintain a high population level. In his report on coyote food habits in the Yellowstone, Adolph Murie (1940) reported field mice in the lead with 33.93 percent, pocket gophers second with 21.61 percent and snowshoe hares as low as 3.4 percent. Similarly, in my own studies in Jackson Hole, Wyoming, just south of the Yellowstone, field mice led with 20.87 percent, pocket gophers came second with 15.69 percent, and snowshoe hares third with 6.92 percent (excluding the item of carrion.)

Here we find that field mice, which are in the lead, and pocket gophers, second, are both unusually abundant and easily obtained. And marmots attain importance by their abundance and ease of capture.

It may be pointed out that such species as *Peromyscus*, *Eutamias*, and *Sciurus*, although acceptable as food, are not often captured. Such animals apparently are not easily caught and do not lend themselves so readily to a routine hunting technic for the coyote. Note, for instance, the well established method of hunting field mice: the watchful pose to detect the presence of a mouse in the grass, then the precise pounce. So thoroughly is this method ingrained in the coyote's inheritance that on one occasion a captive pup, which had never seen a mouse, in a playful mood simulated the mouse hunting technic in our living room with perfect form. The method of hunting pocket gophers has not been observed, but it must have been adequately developed. Certain hawks appear

to have learned to sit beside an open pocket gopher burrow, waiting for the appearance of the occupant.

If I may presume to summarize the feeding habits of the coyote, I may say that usually it seeks an abundant animal form, whose habits are such that it lends itself to easy capture on a scale large enough to furnish a staple food supply; it is alert for any opportunity to pick up other species, vertebrate or invertebrate; and it seeks the areas of big game concentrations, especially in winter, on the chance of carrion, or the chance of finding an animal at a disadvantage. From the economic standpoint, it can be expected that when livestock become easily available, especially when the natural food fails, the coyote readily takes advantage of the opportunity. This could be expected in the North when the snowshoe rabbits fail, and domestic sheep herds are present.

Therefore, the subject of coyote food habits becomes a local problem, not only from the economic standpoint, but also from the standpoint of pure science, depending on the local ecological picture.

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Fish and Wildlife Service, Jackson, Wyoming.

PELAGE CHANGES IN THE SNOWSHOE HARE[1]

(*Lepus americanus struthopus* Bangs)

By Joye Harold Severaid

Perhaps one of the most interesting phenomena in biology is the ability possessed by some animals, such as the snowshoe hare, to change color periodically during the year. For 160 years biologists have sought to determine the actual causes of such changes. No one period produced as many conflicting papers on this subject as the decade preceding 1935, which indicates the confusion of the situation. The following discussion is based on penned animals observed in connection with another study (Severaid, 1942) that afforded an excellent opportunity to observe closely all color changes and to check some of the experiments performed by other writers. It is felt that certain opinions previously advanced have been based on misinterpretation of data.

The writer wishes to acknowledge the assistance and guidance during the field studies and preparation of this paper of C. M. Aldous and John Pearce, past leaders, and Howard L. Mendall, the present leader, of the Maine Cooperative Wildlife Research Unit; and of Dr. Joseph M. Murray, Head of the Department of Zoology, University of Maine. The pen sketches were made by Orman B. Doore from original photographs by the writer. This contribution is from the Maine Cooperative Wildlife Research Unit, Orono, Maine; Maine Department of Inland Fisheries and Game; University of Maine; American Wildlife Institute; and U. S. Fish and Wildlife Service, cooperating.

HISTORICAL REVIEW

The first available opinion relative to an explanation of pelage changes of the snowshoe hare was made by Pennant (1784), who believed that the animals grew a new coat with the approach of winter, but that they retained the original summer coat as well. Richardson (1829) stated the changes were due to a lengthening and blanching of the fur. Thus were established the two opposing theories as to the cause or causes of pelage changes in variable animals, each of which has been expounded alternately in scientific rebuttals ever since. Both Welch (1869) and Merriam (1884) believed that the changes were due to an actual change in the existing hairs, and not to a new growth of pelage. Allen (1894) reintroduced the opposing theory. He explained the color changes as normal molts and the renewal of the pelage by new hairs of different color. Verne (1926), like Welch (1869) believed that the white color of hair is due to air bubbles.

Hadwen (1929), based on a microscopic study of the hair and skin, apparently agrees with Richardson and Merriam. He, too, found air bubbles in the white hair shafts. He noted that hair roots became shrunken and frayed at the ends a few days before the hair itself turns white. "The fact that the roots cease to function as the hair turns white and that it is a progressive change, offers conclusive evidence that the alteration is destructive." His theory met opposition almost immediately. Boyd (1930 and 1932) commented on it

[1] Editor's Note: After this study was completed and presented for publication in 1942, C. P. Lyman (1943) published the results of a similar study conducted at Harvard University, neither author being aware of the other's work. The fact that the two studies, conducted independently, led to similar results lends added weight to the conclusions reached. Severaid has altered his report to indicate wherein Lyman's findings agree or disagree with his own work and that of others he cites. These emendations have been bracketed.

by saying that there is no connection between the living body cells and the wholly dead keratinized cells of the fibers.

Gunn (1932a) in his work on primeness in mammals favors Hadwen's theory, in part, but differs with him on how the change comes about for he showed that it is a characteristic of all mature hair roots to become depigmented and frayed when the prime state is reached. [Confirmed by Lyman, 1943.] In another paper (1932b) Gunn points out that the change that takes place in the hair-roots "cannot be looked upon as a destructive, but rather as a mature phase in the life cycle of the hair. The hair roots must reach this stage before a pelt becomes prime." He further shows (1932a) that primeness may include a depigmentation of the outer hair shaft as well as the root and proximal portion. Hence his theory advanced (1932b) that seasonal color changes in variable animals are due to an exaggeration of the priming process, which takes place annually in all other furbearers to a variable extent, save in albinos. "The nature of the priming and blanching process are therefore the same, the only difference being one of degree."

During this same year Grange (1932) became the newest standard bearer for the theory that the color change is due to the growth of a new coat of white hair. He confirmed J. A. Allen's work (1894) by performing clipping experiments on live animals. Grange found that the portions clipped came into full normal winter pelage at almost the same time as corresponding parts of the body left unclipped. "As there were no individual hairs left to change, no destructive process within the hair could be possible."

Following the comments on his paper (1929) by Boyd, Gunn, and Grange, Hadwen made another study of this subject in which he (1934) like Grange, carried on clipping experiments. His results were similar to those found by Grange, but, because of varying data resulting from experiments made by dyeing the hair, he interpreted his data differently. Hadwen, therefore, persisted in his belief that blanching of the outer parts of the hair occurs in the existing hairs, and that depigmentation of the fur is due to a destructive change. During this study he also found air bubbles in colored hairs; thus, he no longer believes they cause the white coloration although they may enhance the white effect.

All the writers up to the time of Hadwen believed the pelage change in hares was for the purpose of protective coloration. Hadwen (1927), however, stated the belief that color changes are primarily for the summer exclusion and winter retention of heat. Harrington (1927), commenting on Hadwen's (1927) observations regarding the color and health of animals, says that the radiation from the sun is not harmful to the hair itself but rather to the body under the hair. He says black hair prevents radiated heat from reaching the body whereas white hair does not. According to this hypothesis, says Hadwen (1929), white hair should keep the animal warmer at all times with consequent detriment to health in the summer, providing that the skin is not pigmented below it. This he says fits the facts for certain northern animals including the snowshoe hare.

The change of color, says Hadwen (1929), is due to an inherent acquired habit, probably controlled by internal secretions, and environment plays no part. Grange (1932) concluded that, "The changes of pelage are apparently not correlated directly with *immediate* climatic conditions, but they do show a rather remarkable correlation with the *average* climatic conditions, particularly with the presence or absence of snow."

Such was the status of the issue at the instigation of the present study.

RESULTS OF STUDIES ON MARKED SNOWSHOE HARES

Description of the Pelage Changes.—The autumnal and vernal pelage changes follow definite patterns. The fall molt begins on the ears, feet, and legs, and ends along the back. The spring molt nearly reverses the process by beginning on the forehead, nose and body, and ending on the feet and ears. For convenience the stages of change during both seasons, based on the general appearance of the hare, were listed under seven different phases.

(1) *Autumnal pelage changes:*—In the fall the color phases are as follows:

Phase 1. Outer side of ears white (see fig. 1).

Phase 2. White hairs present on outer edges of hind feet (see fig. 2). White predominates to about two inches above tarsal joint late in the phase and some white appears on the back of each front carpal joint, the inner portion of ears and the tip of muzzle.

Phase 3. Feet and legs together with ears and muzzle predominantly to entirely white (except for dorsal portion of front legs, which may remain partially tawny or rufous colored throughout the winter in many individuals). Base of ears and nape also white late in this phase (see fig. 3).

Phase 4. White pelage appearing on breast, shoulders and thighs fanwise from the knees. In early stages region about eyes white, usually extending from muzzle to base of ears. White pelage predominates over most of lower half of body late in this phase (see fig. 4).

Phase 5. White pelage appearing on the upper lateral portion of the body and spreading radially or often appearing over entire body (see fig. 5).

Phase 6. Lateral portions of body predominantly white, dorsal line of dark pelage still present, forehead and cheeks usually brown, a brown eye-ring about one-fourth inch wide (see fig. 6). All of body predominantly white late in phase except for forehead, cheeks and eye-ring.

Phase 7. Early in the phase hare appears completely white except for brown eye-ring, which often fails to disappear (see fig. 7). Animal in full phase after eye-ring is replaced.

Hares are not completely white even in mid-winter. All have an abundance of tawny colored hairs blending with the white ones on the front portion of the ears and a few about the nose and face. Likewise, most of them are predominantly tawny on the dorsal portion of the front feet, lower leg region, and a small area just above the toes of the hind feet. Those appendages that retain this feature during the winter may exhibit two degrees of the color—predominantly tawny, rufous or pale buffy, or a blend of the same with white hairs giving the feet and legs a light brown appearance. Of the 27 adult captive hares in winter pelage observed in this investigation, 15 had appendages dark tawny in color, 5 were light tawny, and the other 7 completely white. For the 29 immature hares, 18 had dark brown feet and legs during their first winter, 9 were light brown, while those of the other 2 were completely white. This may be a genetic trait. Allen (1894) pointed out that this mixture of the winter pelage is due to a growth of new brown hairs.

Observations on the winter color of the vibrissae were made on 20 immature specimens late in December after all were completely or predominantly white. Of these, four had black vibrissae while in 16 they were particolored, black and white. Two of these 16 had vibrissae that appeared to contain more white than black. Hadwen (1934) points out the utility of the vibrissae for showing the disappearance of melanin and that they whiten about the same time as the fur. Observations on this point during this study supported Allen's statements that this feature appears to be a matter of purely individual variation, having no relation to season, although it might be a genetic character.

The degree of whiteness of the winter coat is entirely dependent on the length of the white hair. Some hares fail to obtain a "rich" winter coat. Hare 47 (♀) and one of her young (163) are good examples of this. In both of these specimens the white hairs stopped growing soon after they had surpassed the buffy colored underfur in length. This condition caused both to appear buffy or almost dirty in general appearance, a condition that they retained throughout the winter. The fact that mother and daughter (both apparently healthy) exhibited this character might indicate an inherent tendency for such condition of hair coat.

(2) *Vernal changes.*—The phases of the vernal molt are less distinct and far more variable than the fall changes. For this reason the spring stages are classified according to the approximate area of the body that has assumed the brown coat, or is predominantly brown. Such a method presents some possibilities for discrepancy due to varying judgment of observers, but the degree of accuracy will be rather consistent throughout. The

hare first becomes brown on the forehead, face and nose, followed by brown splotches over the body, then on the hips and shoulders and finally the legs, feet and ears begin to change. The following phases are considered typical of this molt:

Phase 1. Face, forehead, and nose brown, and occasionally partially so on the neck; body faintly mottled as though tinted with brown; estimated body area now brown under 5 percent (see fig. 8).

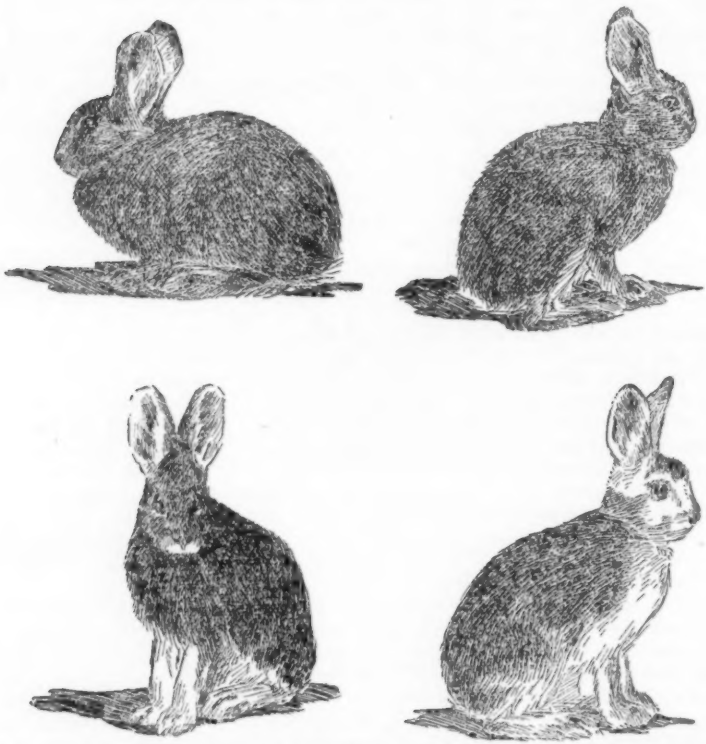

FIG. 1. (Upper left) Phase 1; note white on posterior portion of ears. (These line drawings are characteristic of the various phases in the pelage change as shown in actual photographs in—Severaid, 1942.)

FIG. 2. (Upper right) Phase 2 (late); note abundance of white on hind legs but restricted amount on front legs.

FIG. 3. (Lower left) Phase 3 (late); note abundance of white on legs and ears.

FIG. 4. (Lower right) Phase 4 (late); all of ventral portion of body is white.

Phase 2. Mottling on body quite noticeable; estimated brown between 5 and 15 percent (see fig. 9).

Phase 3. Becoming mottled over rump, hips and shoulders; estimated brown up to 35 percent, head often predominantly brown (see fig. 10).

Phase 4. Body area appears about half brown, either splotchy or very much blended and not spotty, appearing roan in color; estimated up to 55 percent brown,

head usually almost brown except for ears and patches of white on cheeks. (see fig. 11).

Phase 5. Body predominantly brown, estimated up to 80 percent; breast, throat and belly, lower rump and ventrolateral abdominal region show intermingling white hairs; ears, cheeks, feet and legs usually white at this stage; scattered white guard hairs may be present over entire body (see fig. 12).

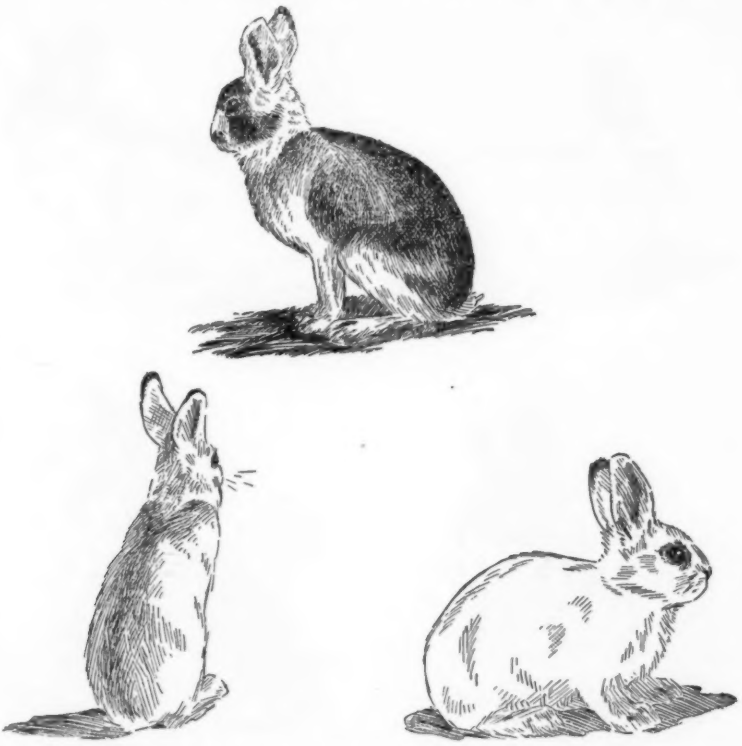

FIG. 5. (Top) Phase 5 (late); note facial pattern.
FIG. 6. (Lower left) Phase 6; note more blended pattern.
FIG. 7. (Lower right) Phase 7 (early); note partial brown eye-ring.

Phase 6. Hare mostly brown, estimated up to 95 percent brown; only belly, lower abdomen, ears and legs still partly white or with scattered white hairs; few scattered white guards may still remain over body proper (see fig. 13). Black guard and variegated summer pile hairs begin to appear over ridge of back.

Phase 7. This stage is characteristic of the normal summer pelage; animal 95 to 98 percent brown; body completely so except for belly, which is white throughout the year; tarsal and metatarsal areas often still predominantly white early in this phase causing the hare to appear similar to fall phase 2 or 3; summer pile and guard hairs becoming prominent over most of body,

completely so over entire body later in this phase except for varying amounts of white on the metatarsal portion of the hind feet, which may remain partly white throughout the summer (see fig. 14). After losing the white pile and guard hairs, the animal appears rusty red or rufous colored for a time due to the presence of the underfur, which sheds more slowly and is not fully lost until after the new spring growth surpasses it. The dorsal

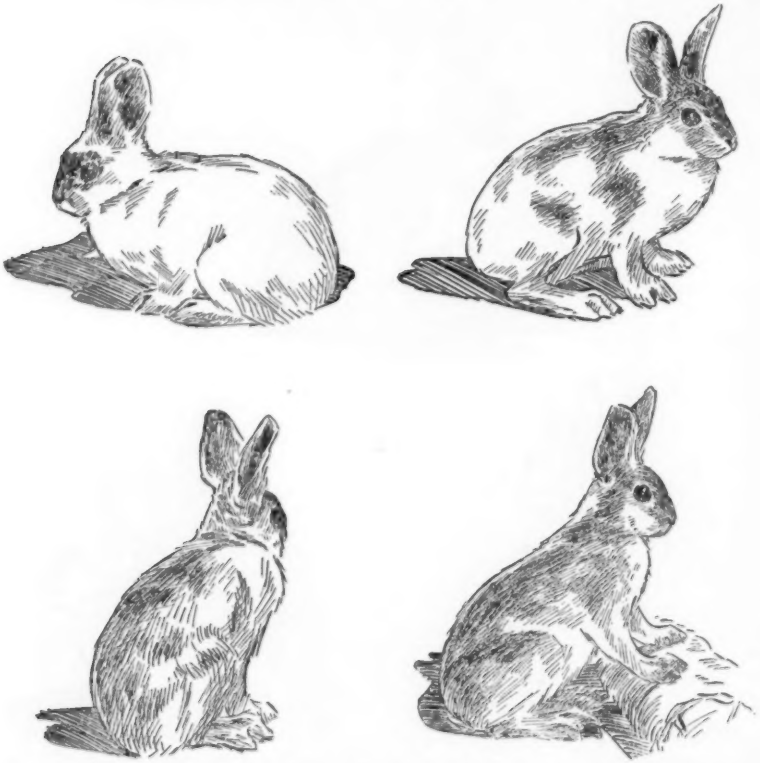

FIG. 8. (Upper left) Phase 1; note loss of white hair on face.
FIG. 9. (Upper right) Phase 2 (early); note beginning of change on body and further browning of head.
FIG. 10. (Lower left) Phase 3 (early); note splotchy loss of white hair over body.
FIG. 11. (Lower right) Phase 4; shedding becoming profuse over entire body.

mid-line of the body is the first area to assume the true black-tipped, variegated pile hairs of the summer coat. This condition then spreads ventrally until the entire upper body has become so colored.

The periods of change.—During this study, records were kept to determine the periods over which the color changes occur under conditions existing in Maine. Tables 1 to 3 show the approximate time of beginning and ending of each autumnal molt and the interval between each phase for each of the experimental hares. It must be remembered that all the hares did not follow the typical pattern exactly, but variations were usually slight.

From data gathered on 9 males and 18 females during the fall of 1939, it was found that the first blanching on the ears appeared about October 1. In the fall of 1940, however, (based on 11 males and 17 females) the ears of a few showed blanching about September 20. By October 1, the ears of 68 percent had begun to change and on some even the hind feet. Although 71 percent had entered Phase 1 by October 1 in 1939, none had reached Phase 2 by this date, whereas in 1940, 8 (29 percent) were in Phase 2 by October 1. In 1939 the first hare had completed the molt by November 21 and the last by January 6. The

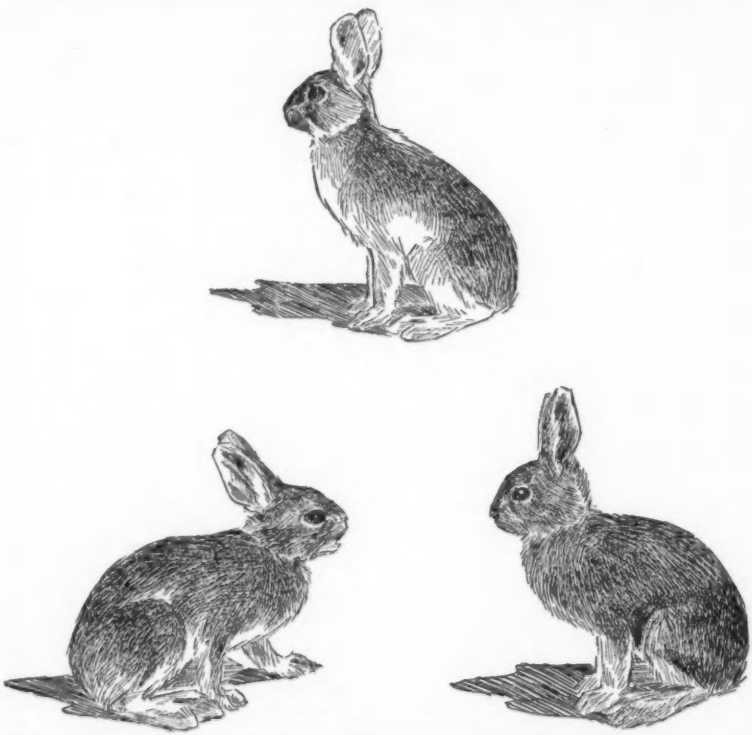

FIG. 12. (Top) Phase 5 (late); note resemblance to autumnal phase 4 (see fig. 4).
FIG. 13. (Lower left) Phase 6; undercoat usually still longer than new growing summer pile and guard hairs.
FIG. 14. (Lower right) Phase 7 (early); full summer pelage over body but change on feet and ears still incomplete. Note resemblance to autumnal phase 3 (see fig. 3).

first hare to complete the change in 1940 did so by November 25 and the last by January 12, 1941.

The first heavy snowfall of the 1939 season fell during the last week in November. Table 1 shows that at this time the hares ranged in color from Phase 3 through Phase 7 with most of them in Phases 5 and 6. In the fall of 1940, the first important snowfall occurred November 26 and 27. At this time the variation in color was similar to that recorded for the previous fall with Phases 5 and 6 again being the most common (see Table 2). There were light snows earlier in November of both years. At that period the pelage changes were much less advanced. The changes begin early in October, fully a month before snow is

to be expected in this locality. These conditions indicate, therefore, that initial pelage changes in the snowshoe hare are not dependent on snow conditions.

The interval of change in Maine was similar to that found for Ontario by Hadwen (1929), for Wisconsin by Grange (1932), and for Minnesota by Aldous (1937). The reports of Hadwen seem to indicate that the change starts slightly earlier in Ontario than in Maine and its equivalent latitude.

TABLE 1.—*Observations on the autumnal molt of 27 snowshoe hares—1939*

HARE NO.	PHASE NO.													SEX	TOTAL DAYS REQUIRED
	October			November				December				January			
	1	9	20	1	7	14	21	1	8	15	22	1	6		
3	1	−2	−2	3	3	3	−4	+4	+5	7	—	—	—	♂	76
7	1	−3	−3	4	4	4	+4	+6	7	—	—	—	—	♂	67
9	1	1	+2	3	3	−4	4	5	7	—	—	—	—	♂	69
21	1	−3	3	−4	4	4	5	7	—	—	—	—	—	♂	60
27	1	−2	+2	+2	−3	3	4	−5	+5	6	7	—	—	♂	83
46	0	1	2	−3	3	+3	+3	4	4	−5	6	+6	7	♂	89
61	0	1	−2	2	−3	+3	−4	4	+5	6	7	—	—	♂	74
65	1	−2	2	+2	−4	−4	+4	6	+6	7	—	—	—	♂	76
78	1	−3	+3	+3	−4	4	5	+6	7	—	—	—	—	♂	69
4	1	−2	2	2	−3	3	3	+4	+5	6	7	—	—	♀	83
5	1	−2	3	−4	−4	−4	+4	7	—	—	—	—	—	♀	60
10	0	−1	+2	3	−4	−4	5	7	—	—	—	—	—	♀	52
11	0	1	−2	+3	−4	−4	+4	6	7	—	—	—	—	♀	60
15	0	1	−2	3	3	3	3	+3	+3	4	5	+6	7	♀	89
17	1	2	−3	3	3	+3	−4	+4	+5	6	7	—	—	♀	74
24	1	−2	−3	3	−4	4	5	7	—	—	—	—	—	♀	61
44	1	2	2	2	−4	−4	−5	6	7	—	—	—	—	♀	69
45	1	−2	2	+2	−3	−4	4	5	−6	+6	7	—	—	♀	83
47	1	+3	+3	−4	4	5	6	7	—	—	—	—	—	♀	61
48	1	−3	3	+3	−4	+4	6	7	—	—	—	—	—	♀	61
49	0	1	1	−2	+2	−3	+3	5	6	−7	7	—	—	♀	74
51	1	−3	−3	−3	−4	4	4	6	7	—	—	—	—	♀	69
52	0	0	2	2	−3	+3	−4	+5	+5	6	7	—	—	♀	67
55	1	+2	+3	+3	6	+6	7	—	—	—	—	—	—	♀	52
57	1	−3	3	3	−4	4	4	6	7	—	—	—	—	♀	69
60	1	2	2	3	−4	−4	4	+5	6	7	—	—	—	♀	76
64	1	2	−3	+3	−4	−4	4	+5	6	7	—	—	—	♀	76

−2 = early Phase 2.
+2 = late Phase 2.

The 1939 fall molting period averaged 71 (52 to 89) days (Table 1). The average for 1940 was 78 (54 to 107) days (Table 2). This longer period of molt is not so unusual as it may seem. In the fall of 1939 all hares were considered to be in Phase 7 as soon as the forehead turned white. The importance of the brown eye-ring in the color change was not realized until 1940. Reference to Table 2 will show that nearly a month was required to lose the brown eye-ring. In a few cases this ring disappeared before the brown on the forehead, and an occasional hare failed to lose all of the brown eye-ring, while on two others new brown hairs grew in about the eyes causing them to regain partially the eye-ring. Its significance in computing the period of change was appreciable since it added an average of

6 days. Consequently, 72 days would be the 1940 figure comparable to the data for 1939 (71 days). These data are remarkably alike over the two-year period, but, due to more experience, those for 1940 (Table 2) are probably the more representative. It must be borne in mind that although the time taken for the color changes is recorded in a definite number of days, these figures are conservative for they include only the period during which the change is noticeable to the eye. The change has been in progress for several days before it becomes noticeable and doubtless continues slightly after it appears to be complete.

Aldous (1937) suggested that females require less time than males to complete the molt, starting and completing it earlier in the season. Corroborating observations were made during this study. The average number of days needed by 18 females to make the autumnal change in 1939 was 69 days whereas 9 males took 74 days. However, the two hares that took the shortest and longest periods were both females. Again in the fall of 1940 the males took longer to change than the females, requiring 84 days as against 75 days for the females. A male took the longest time in 1940 (107 days), and a female the shortest (54 days). Sixty-nine days was the shortest period taken by a male and 94 days the longest by a female (Table 2), except one female, no. 49, that obviously was not normal. There wasl ess variation in the time taken by the two sexes in young hares (Table 3). For the immature, 13 males took 90 days while 15 females took 89 days. This difference is probably not significant considering the method of recording data.

Grange (1932) suggested that young hares required longer than adults to complete the fall change. Table 3 shows that 28 immature hares averaged 89 days or 11 days longer than the adults. In general, the adults begin the change about one week earlier than the young. The eye-ring seemed to be a chief factor in prolonging the change of juveniles. The young averaged 9 days, or 3 days longer than the adults, in losing the eye-ring. The shortest period recorded for a young to complete the change was 77 days. Seven completed the molt in this time. At the other extreme four required 105 days, but these all took a month to lose the eye-ring so that most of the change occurred in a much shorter period. It was interesting to note that the offspring of ♀ no. 115, born August 29 (her fourth litter of the year) began to show white on the ears late in October when but two months old.

No vernal color change was noticeable before March 1, when two females showed some darkening about the face and back. By March 7 their entire bodies were mottled. Practically all the hares were in Phase 1 by March 15 (Table 4). Most of them were approximately 90 percent brown by the last week in April. This is an average of about 50 days for the bulk of the change. However, close observation showed that the change was not complete at this time. The feet, lower regions of the legs, portions of the ears and ventrolateral portions of the body were still in winter coat. Frequently, it took a hare almost as long to complete the last 10 percent as all the rest of the change required. The loss of the white pile and guard hairs was often rapid, leaving the hare cinnamon colored or tawny due to the appearance of the undercoat at this time. Yet, the change was really not complete until the entire body had attained its new coat of variegated pile and guard hairs. Such conditions apparently were the basis for Grange and Aldous stating that the vernal molt required less time. These data were based partly on observations made in the wild and consequently the feet and legs, as well as the condition of the pile and guard hairs, did not lend themselves to sufficiently close observation or possibly did not receive full consideration as regards their importance in the color change.

The average time taken for both sexes to complete fully the vernal change in 1940 was 71.8 days; for 11 males, 72 days; for 24 females, 69 days. Again the females seemed to make the change a little faster than the males. Yet, two of the slowest were females and a male took the least time. This male took only 49 days while one of the females took 94 days and the other retained a portion of her winter pelage until her death in late June.

From these observations it appears that females, with occasional exceptions, require less time to molt. Likewise they appear to start and complete it earlier in the season. These data support those recorded by Aldous (1937) in Minnesota.

It appears that the average time required for both sexes combined to make the change

in Maine is slightly less than reported by Grange for Wisconsin. He reported the autumnal change to take 70 to 90 days and the vernal change 70 or more days.

The Manner of the Pelage Changes.—Observations made during this study showed inconsistencies in the manner of pelage changes from that recorded by certain authors. In

TABLE 2.—*Observations on the autumnal molt of 28 snowshoe hares—1940*

HARE NO.	PHASE NO.															SEX	TOTAL DAYS REQUIRED
	October				November				December					January			
	1	8	15	22	1	8	17	25	1	8	15	22	29	6	12		
27	−2	−2	+2	3	−4	−4	4	4	5	5	+6	−7	7	—	—	♂	*93
61	−1	−2	2	+2	3	+3	−4	4	4	5	6	7	—	—	—	♂	83
67	−1	−2	2	+2	+3	−4	4	4	5	6	7	—	—	—	—	♂	76
78	2	−3	+3	−4	4	−5	+5	+6	7	—	—	—	—	—	—	♂	76
81	+1	2	−3	−3	−4	4	4	+5	6	+6	−7	−7	7	—	—	♂	94
82	−2	+2	+3	−4	−4	−4	4	5	6	−7	−7	7	—	—	—	♂	86
85	−1	2	+2	+3	−4	4	−5	+6	−7	7	—	—	—	—	—	♂	69
86	0	0	−2	2	−3	3	+3	4	4	5	−6	+6	7	—	—	♂	75
92	−2	−2	+2	−3	−4	−4	−4	4	5	+5	+6	+6	+6	−7	7	♂	107
119	−1	+2	+3	+3	4	4	4	5	+6	−7	−7	−7	7	—	—	♂	90
121	−2	2	−3	+3	−4	−4	4	+5	−7	7	—	—	—	—	—	♂	72
4	−1	1	2	−3	+3	−4	−4	4	5	5	+6	7	—	—	—	♀	83
24	−1	−2	2	+2	3	−4	−4	4	5	6	+6	7	—	—	—	♀	83
47	0	2	−3	+3	−4	−4	−4	−4	−4	−4	+5	6	+6	7	—	♀	94
48	1	2	3	3	−4	−4	4	5	+6	7	—	—	—	—	—	♀	72
49	0	0	0	0	−1	−2	−2	−2	−2	−2	−2	+2	+2	+2	+2	♀	—
55	2	3	−4	4	−5	6	−7	7	—	—	—	—	—	—	—	♀	63
84	−1	2	+2	−3	−4	−4	4	6	−7	7	—	—	—	—	—	♀	69
88	0	+1	2	−3	+3	−4	−4	4	+4	5	6	−7	−7	7	—	♀	93
96	−2	2	2	+3	−4	−4	−4	+4	5	6	−7	−7	7	—	—	♀	93
98	−2	2	−3	−4	4	4	5	6	−7	7	—	—	—	—	—	♀	72
106	−1	−2	2	+2	3	−4	4	−5	5	+6	7	—	—	—	—	♀	76
110	0	0	−1	−2	2	3	−4	4	+4	+5	6	7	—	—	—	♀	68
111	0	0	−1	−2	2	−3	+3	4	5	5	6	−7	7	—	—	♀	75
112	0	1	+2	−3	3	−4	4	5	6	−7	7	—	—	—	—	♀	68
113	−1	2	2	−3	+3	+3	−4	4	−5	6	7	—	—	—	—	♀	76
114	0	−1	2	+3	−4	−4	4	5	6	7	—	—	—	—	—	♀	61
115	0	0	0	+1	2	−4	4	−5	+5	−7	7	—	—	—	—	♀	54

−2 = early Phase 2.

+2 = late Phase 2.

* In some cases the total number of days is greater than the recorded data would indicate. This difference is due to the fact that in those cases the hares had begun to show a change at the time of the first observation. The estimated difference was therefore included in the final number of days required to make the complete change.

an endeavor to elucidate the issue, several experiments were performed, patterned after those made by these authors.

(1) *Experimental procedure.*—Each hare was examined weekly to record weight and growth data. While in the hand, close color observations were made by parting the hair with the fingers. By the time the hares had reached Phase 4 of the color change (the ears, feet, legs and lower thigh and shoulder regions predominantly white), the rest of the body,

when observed casually from a distance still appeared completely brown. But when the hair was parted an abundance of short white hairs was seen. These were definitely new because in the beginning they were all shorter than both the existing pile hairs and the plumbeous underfur, and could be followed in their growth (most easily on the body) from the time they first appeared, early in about Phase 3, until they were as long as the brown pile hairs. Phase 3 was used here simply as a convenience for the short hairs were

TABLE 3.—*Observations on the autumnal molt of 28 young snowshoe hares—1940*

HARE NO.	PHASE NO.																SEX	TOTAL DAYS REQUIRED
	Sept. 29 to Oct. 5	Oct. 6 to 12	Oct. 13 to 19	Oct. 20 to 26	Oct. 27 to Nov. 2	Nov. 3 to 9	Nov. 10 to 16	Nov. 17 to 23	Nov. 24 to 30	Dec. 1 to 7	Dec. 8 to 14	Dec. 15 to 21	Dec. 22 to 28	Dec. 29 to Jan. 4	Jan. 5 to 11	Jan. 12 to 18		
130	−2	2	2	+2	+3	−4	−4	+4	5	6	−7	7	—	—	—	—	♂	85
134	−2	2	+2	3	−4	−4	+4	5	6	+6	−7	−7	7	—	—	—	♂	91
143	1	−2	+2	−3	−4	−4	+4	−5	+6	−7	−7	7	—	—	—	—	♂	77
144	−1	+1	+1	−2	−2	3	−4	−4	−5	+5	6	+6	−7	−7	−7	7	♂	105
155	1	2	+2	−3	+3	+3	−4	4	5	+6	+6	+6	7	—	—	—	♂	91
156	1	−2	+2	3	−4	−4	−4	−5	6	+6	+6	+6	+6	−7	−7	7	♂	105
159	1	−2	−2	−3	−4	−4	5	6	+6	−7	−7	−7	7	—	—	—	♂	91
161	−1	+1	−2	2	3	+3	−4	−4	−5	6	+6	−7	7	—	—	—	♂	91
170	0	1	1	−2	2	3	−4	+4	6	−7	−7	7	—	—	—	—	♂	77
181	0	−1	1	2	−3	3	−4	4	4	−6	6	+6	−7	−7	−7	7	♂	105
182	0	1	1	2	3	+3	−4	−4	4	5	+5	+6	+6	7	—	—	♂	91
184	1	−2	2	−3	+3	−4	−4	−5	+6	+6	−7	7	—	—	—	—	♂	77
188	1	2	2	−3	−4	−4	4	5	+5	6	+6	7	—	—	—	—	♂	84
131	1	1	−2	2	3	+3	+3	−4	−5	5	+6	7	—	—	—	—	♀	84
139	0	−1	−2	2	−3	+3	+3	+3	−4	+4	+5	6	−7	7	—	—	♀	91
149	0	0	2	2	−3	3	3	+3	4	5	+5	+6	+6	−7	−7	7	♀	97
152	1	2	2	−3	−4	−4	4	+5	−6	6	7	—	—	—	—	—	♀	77
153	1	−2	2	−3	+3	−4	4	+5	+6	−7	−7	7	—	—	—	—	♀	77
158	0	−1	−2	2	3	+3	−4	−5	6	+6	+6	−7	7	—	—	—	♀	91
160	1	−2	−2	+2	3	−4	+4	6	+6	−7	7	—	—	—	—	—	♀	77
163	0	0	1	1	−2	2	−3	+3	−4	−5	+6	+6	7	—	—	—	♀	77
164	0	−1	+1	−2	2	−3	3	+3	4	−5	6	+6	+6	−7	−7	7	♀	98
168	0	−2	−2	2	+2	+2	4	−5	6	+6	+6	−7	7	—	—	—	♀	84
171	1	−2	2	2	−3	3	−4	−5	6	+6	−7	−7	7	—	—	—	♀	84
178	1	−2	−2	2	3	3	+3	−4	−5	+5	+6	+6	−7	−7	7	7	♀	105
183	0	1	1	1	1	−2	+2	+3	−4	5	5	+6	−7	−7	7	—	♀	98
186	0	1	1	1	−2	2	+2	−3	−5	+5	6	+6	−7	7	—	—	♀	91
187	0	−1	1	1	1	2	3	3	4	5	−6	+6	+6	7	—	—	♀	91

−2 = early Phase 2.
+2 = late Phase 2.

more easily seen on the body proper than on the appendages. They could be seen on the limbs during Phases 1 and 2, but were practically mature there before the new body hairs became visible. At no other season of the year were these white hairs seen intermingling with the underfur.

If the whiteness of the coat is due to a growth of new white hair, then clipping the brown hair should expose the white hair sooner. This was found to be true as it was in the studies by Grange (1932) and Hadwen (1934). Shortly after the ears began to show white hairs on the posterior portion, hare 134 (Experiment 1) was clipped on the left ear, thigh, and

TABLE 4.—*Observations on the vernal molt of 39 snowshoe hares—1940*

HARE NO.	PHASE NO.								SEX	NO. DAYS TO FINISH	TOTAL DAYS REQUIRED
	March				April			May			
	1	7	15	26	6	19	30	14			
27	0	1	2	3 (25%)	3 (30%)	6 (95%)	7 (99%)	7 (100%)	♂	0	68
46	0	1	2	3 (40%)	4 (50%)	6 (85%)	6 (95%)	7 (98%)	♂	14	82
61	0	−1	−2	4 (50%)	5 (70%)	6 (85%)	7 (98%)	7 (99%)	♂	7	75
67	Caught in traps after change had begun					5 (70%)	6 (95%)	7 (96%)	♂	21	—
78	0	0	0	3	+3	4 (50%)	6 (85%)	7 (96%)	♂	21	76
81	0	0	0	0	1	6 (85%)	7 (99%)	7 (100%)	♂	0	49
82	0	0	0	+1	2	5 (60%)	7 (96%)	7 (98%)	♂	14	68
83	0	0	1	−3	4	6 (90%)	6 (95%)	7 (98%)	♂	14	71
85	0	0	2	2	2	6 (90%)	7 (98%)	7 (98%)	♂	14	74
86	Caught in traps after change had begun					5 (60%)	6 (90%)	7 (96%)	♂	21	—
92	0	1	3	3	3 (20%)	5 (70%)	7 (98%)	7 (98%)	♂	14	79
117	0	0	0	−2	−2	4 (50%)	6 (80%)	7 (98%)	♂	14	74
119	0	0	3	3 (30%)	5 (60%)	6 (80%)	7 (96%)	7 (98%)	♂	14	74
121	Caught in traps after change had begun						4 (40%)	6 (90%)	♂	35	—
4	0	0	1	4 (50%)	5 (60%)	7 (98%)	7 (99%)	7 (99%)	♀	7	68
17	0	1	2	5 (60%)	5 (70%)	7 (98%)	7 (99%)	7 (100%)	♀	0	68
24	0	0	1	4 (40%)	5 (60%)	7 (98%)	7 (98%)	7 (98%)	♀	14	74
47	0	0	1	+2	3 (20%)	6 (85%)	6 (95%)	7 (98%)	♀	14	73
48	0	−1	−2	3 (25%)	4 (50%)	5 (60%)	6 (85%)	7 (96%)	♀	21	89
49	1	2	+2	5 (75%)	6 (95%)	7 (98%)	7 (99%)	7 (100%)	♀	0	68
52	0	1	2	4 (40%)	4 (55%)	6 (95%)	7 (99%)	7 (100%)	♀	0	61
55	0	1	2	3 (25%)	3 (30%)	5 (80%)	6 (90%)	7 (96%)	♀	28	96
84	0	1	2	4 (40%)	5 (70%)	7 (98%)	7 (99%)	7 (100%)	♀	0	68
87	0	0	−2	−2	2 (15%)	6 (85%)	7 (96%)	7 (98%)	♀	14	74
88	0	1	3	4 (55%)	5 (65%)	6 (85%)	6 (95%)	7 (98%)	♀	14	82
89	0	1	2	−3	4 (40%)	6 (85%)	7 (99%)	7 (99%)	♀	7	72
96	0	0	1	2	3 (25%)	6 (90%)	7 (96%)	7 (98%)	♀	14	74
98	0	1	2	3 (25%)	4 (50%)	6 (95%)	7 (99%)	7 (100%)	♀	0	68
103	0	0	1	2	3 (25%)	7 (96%)	7 (98%)	7 (98%)	♀	7	68
104	—	—	—	—	—	5 (80%)	6 (95%)	7 (99%)	♀	7	—
105	0	1	2	−3	3 (20%)	4 (40%)	7 (98%)	7 (100%)	♀	0	68
106	0	1	2	+2	+2	3 (25%)	6 (90%)	7 (100%)	♀	0	68
110	0	1	2	4 (40%)	4 (40%)	7 (98%)	7 (98%)	7 (99%)	♀	7	74
111	0	0	−2	2 (15%)	3 (30%)	6 (90%)	7 (98%)	7 (99%)	♀	7	67
112	0	0	1	2	3 (30%)	6 (90%)	7 (99%)	7 (100%)	♀	0	58
113	0	1	2	−3	2 (15%)	4 (40%)	6 (90%)	7 (98%)	♀	14	78
114	1	−2	+2	3 (30%)	5 (60%)	7 (98%)	7 (99%)	7 (100%)	♀	0	68
115	0	0	−2	2	3 (30%)	6 (90%)	7 (98%)	7 (99%)	♀	7	67
120	—	—	—	—	—	5 (80%)	6 (85%)	6 (95%)*	♀	—	—

−2 = early Phase 2.

+2 = late Phase 2.

* In the case of this animal, even as late as June 16 the pelage change was only 96% complete.

lateral abdominal region on September 16, 1940. The ear rapidly became furred again but the new hair was white in color. The thigh and abdomen, which had only the pile and guard hairs removed, showed no signs of new growth until approximately October 20. During the summer, less time than this was required for a sloughed-off patch of skin to become fully furred with new brown fur. On October 30 the whole clipped area on the thigh was white and closer observation showed the whiteness to be due to pile and guard hairs. The undercoat was still the plumbeous color of summer, but there was also much tawny-tipped or rufous colored underfur intermingled with it. These were new hairs, too, for they were longer than the plumbeous undercoat. The clipped area on the side of the body was still coated with nothing but underfur on this date and the right thigh was still normal brown when observed from a distance. The pile and guard hairs were then plucked, not cut, from the right thigh to correspond with the area on the left thigh. This simple procedure immediately made both thighs appear equally white. By November 20 the

TABLE 5.—*Completion dates for pelage changes in snowshoe hares*

DATE	MALES		FEMALES	
	Number that had completed the change		Number that had completed the change	
	1939	1940	1939	1940
Nov. 21	—	—	1	—
Nov. 25	—	—	—	1
Dec. 1	—	1	2	5
Dec. 8	2	3	5	—
Dec. 10	5	—	8	—
Dec. 12	6	—	10	—
Dec. 13	—	—	11	—
Dec. 14	—	—	12	9
Dec. 15	7	4	13	—
Dec. 16	—	—	14	—
Dec. 17	8	—	—	—
Dec. 18	—	—	17	—
Dec. 22	—	6	—	12
Dec. 29	—	10	—	14
Jan. 3	—	—	18	—
Jan. 6	9	—	—	16
Jan. 12	—	11	—	—

clipped abdominal area (left side) was fully furred with new white hair (see fig. 15). The right side was still predominantly brown. Again plucking the brown summer pile hairs exposed the shorter winter pile hairs and almost immediately transformed the right side to the same degree of whiteness as that of the left (see fig. 16).

On December 19 after both these clipped areas had had an opportunity to obtain their full winter coat, bunches of the fur from them were clipped and glued between two layers of cellulose tape for permanent record. Observations on these with a binocular microscope failed to show cut distal ends on the hairs from the dorso-lateral area. Only a few tips of the longer guard hairs from the thigh region exhibited such cuts.

Experiment 2 with hare no. 139 was a check on Experiment 1. This animal was similarly clipped on November 20, in late Phase 3. Here the new hair coming in on the dorso-lateral area corresponded in length to about that which could be expected of the new hairs on the thigh region when the animal was in Phase 1, such as was true of hare 134 (Expt. 1) when it was clipped on September 16. Microscopic examination of these hairs after

they reached maturity showed those from the dorso-lateral area of hare 139 had no cut ends. Apparently they were still too short to be affected by the clipping. The hair from the thigh region on this animal did show numerous cut ends but this was because the new white hairs had become quite long there by the time the animal had reached Phase 3. Consequently, clipping the area affected most, but not necessarily all, of the white hairs as some were slower growing and were persistently shorter than others. These experiments prove conclusively that the white hair of winter is of new growth.

Further indication that the summer pile and guard hairs were shed in the fall was shown by hares 166 and 161. Hare 166 reached Phase 4 and then lost all of its pile and guard hair before the rest of the body became white. The white hair was short and apparently had stopped growing. This specimen was killed to preserve the record. Hare 161 also shed most of its summer pile and guard hairs long before its growth of white hair was complete. However, both of these animals were abnormal. They had suffered from coccidiosis earlier in the season. Hare 161 lived through the winter and eventually grew a complete winter coat.

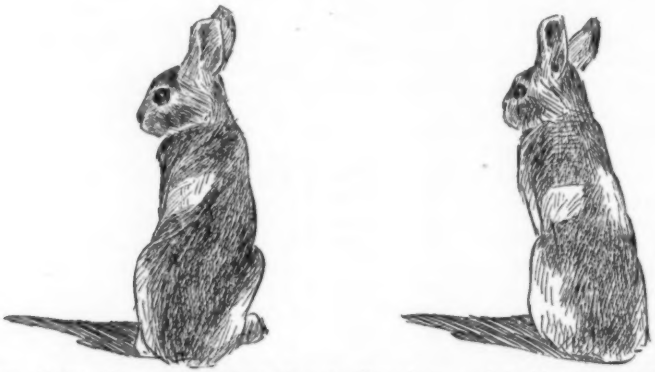

FIG. 15. (Left) Hare no. 134 (Expt. 1); note clipped area on left side of body which has grown in to white hair, unobstructed by intermingling brown summer hair.

FIG. 16. (Right) Hare no. 134 fifteen minutes later, after summer pile hair was hand-plucked from right side of body.

Another question regarding the pelage changes of these hares concerns the shedding of the underfur in the fall, a condition that as yet has not been definitely ascertained. Hadwen (1929 and 1934) says that hares may molt some in the fall but that it is not a heavy molt. Inasmuch as it is the undercoat and not the pile and guard hairs that are principally responsible for maintaining body temperature, this belief seems plausible. Two of Hadwen's experiments (1934) lend further support to such a theory.

With respect to the undercoat, Allen (1894) says: "Whether or not the soft underfur is also shed in autumn, cannot readily be determined; but from its increased length and abundance in winter, as compared with summer and early autumn, it is evident that, if not wholly renewed, it at least is greatly augmented."

Allen's conclusion was reached from observations on museum specimens. It has been substantiated by the following experiment: Hare 149 (see Expt. 3) in Phase 4 was plucked on one side November 25. This plucking included the plumbeous underfur, also the pile and guard hairs. Not only did short white hairs appear after this plucking but considerable equally short, rufous-tipped hair of the underfur type also remained. These hairs were all less than two millimeters in length and consequently too short to be affected by

plucking. Within a week this new fur was almost half as long as the bordering old plumbeous colored underfur, but not quite so dense. An area on the body of sufficient size was so treated to show conclusively that this condition existed over the whole body at that time. This indicates without a doubt that the underfur is at least greatly augmented during the autumnal change. [Lyman (1943—p. 416) gives proof that three molts a year take place, the third being a preliminary autumnal molt during August and September. At this time the underfur is apparently renewed.]

To experiment further on the growth rate of the hair, perhaps to determine how long the respective coats remain on the body and also to learn what effect interference with the pelage might have, Experiment 3 was continued as follows:

November 25, 1940.—All hair, including undercoat, was plucked from most of the right side of body (Area 1) Short new white hair and a rufous colored underfur were present next to the skin. These hairs were abundant and too short to be affected by plucking. They were obviously of new growth. An attempt to pluck the thigh region was unsuccessful for the hare was in Phase 4. Consequently, the new growth of hair was sufficiently long on the thigh region to be mixed with the summer fur. It could not, therefore, be separated from the latter and plucking resulted in injury to the skin, whereas no injury resulted where the new hair was not long enough to be plucked.

December 2.—Area 1 was by now half-grown-out to new white and rufous colored hair.

December 9.—Area 1 was now almost equal in length to the unplucked hair. The new coat appeared to be less dense than on the unplucked side, however. Presumably, the plumbeous undercoat is not shed in the fall.

December 16.—The hair on Area 1 was now no different from unplucked hair. Therefore, it grew out fully in three weeks. The hare was now in a late Phase 6. Area 2 was now plucked on same place as that of Area 1. The skin was now bare.

December 23.—Clipped Area 3 bordering Area 2. Only the underfur was left but the bases of the white pile and guard hairs were easily visible as they were interspersed with the underfur. There was as yet no sign of new hair growing in on Area 2.

December 29.—Area 2 had become completely covered with fine silky brown hair together with interspersed white hairs. Length was less than one millimeter. A new Area (no. 4) was plucked bare adjacent to Area 2.

January 6, 1941.—By now extensive growth had taken place on Area 2 plucked December 16. Area 4 plucked December 29 showed no new hair.

January 12.—Hair in Area 2 was now one-half as long as the mature hair. A new growth of silky brown hair had appeared on Area 4. Area 3, which had been clipped rather than plucked, still showed no apparent growth. Therefore, a new Area, no. 5, was plucked bare in the central portion of Area 3. No new hair was present near the skin.

January 20.—Area 5 showed no new growth of hair but Area 1 was now white again, fully grown, and like the surrounding mature winter hair. All the other areas were becoming white but were of varying lengths.

January 27.—Area 5 now showed a new growth of silky brown hair with white hairs interspersed; the length was less than one millimeter.

February 8.—Hare 149 died from being harassed by a dog. At the time of its death the hair on Area 5 was already longer than the hair of Area 3, which had been clipped on December 23 and still showed no growth. Hare 178 was chosen as the subject for the balance of the experiment.

February 9.—Plucked Area 7 (first area plucked on hare 178) leaving the skin bare. There was no sign of new hair present when the old hair was plucked.

February 21.—Area 7 had become dark blue and the hair barely protruded. Area 8 was now plucked; no new growth of hair was evident.

March 1.—The hair on Area 7 grew in brown as in summer; it was now 5 millimeters long. Area 8 had become blue (unprime) but no hair appeared through the skin. Area 9 was then plucked; no new growth of hair was apparent.

March 31.—All plucked areas on hare 178 were made up entirely of brown summer hair.

Area 10 was now plucked. New hair was present next to the skin. The growth was spotty rather than uniform and was four millimeters long at that time. The animal was in an early 3 vernal color phase, and about 15 to 20 percent brown.

April 12.—The animal was now about 85 percent brown. Area 10 was now fully furred but not completely grown out. Some underhair was also present. Area 11 was now plucked adjoining Area 10 and both areas looked alike. Experiment terminated on this date.

Results (Expt. 3).—Several conclusions may be reached from this experiment. It shows, first, that mature hair may be shed or lost completely without injury to the skin, whereas new hair cannot be so lost without injury. In this respect, Gunn (1932a) points out that the unprime or pigmented hair roots originate in the deepest part of the dermis and are arranged at a very acute angle to the surfaces while in the fully prime pelt the hair roots are situated in the outer half of the dermis and are almost vertical to the surface. This would explain the loss of mature hair without injury. The old prime summer hair plucked easily but the new white hairs were so deeply rooted while yet growing that an attempt to pluck them resulted in the removal of skin. As was expected, the white hair would pluck without injury to the skin as soon as it reached maturity. By December 16, just three weeks after the original plucking of hare 149, the new hair was apparently mature so the same area was again plucked without injury to the skin.

This characteristic of prime hair was also noticed indirectly through the weekly handling of the animals. When they were changing from brown to white large quantities of brown hair brushed off, often in large bunches. This was not characteristic of the white hair until after the animals became predominantly white, after which the white hair sloughed off in quantities almost equal to that of the brown hair in the fall.

Second, the experiment shows that new hair will regenerate in an area where it is completely lost and that the new hair so grown always has the same characteristics as the rest of the pelage, or those to which the pelage is tending at the time the new hair begins to grow. [Confirmed by Lyman, 1943.] This lends support to the theory that there are two different sets of hair roots each with its respective active and dormant periods. Gunn (1932a) reports that the papilla from which the hair grows remains in the deeper part of the dermis, even after the mature hair root migrates away from it, and is surrounded by a remnant of epithelial cells from which the next generation will probably arise.

Those areas that were clipped, however, showed no regrowth of the hair but remained short until replaced by a new growth. Hadwen (1934) reported a similar condition. He cut patches of white hair from a snowshoe hare after it had reached maximum growth and found no regrowth for 51 days, after which the pointed ends showed the growing hair to be new. Although it was not stated, it is presumed this new growth was brown.

Apparently, so long as the roots of the mature hairs remain intact there is no further growth in the mature hair (or if any occurs it is so slow as to be unnoticeable even over several weeks), but if the hair roots are lost, the vestigial cells referred to by Gunn immediately start to regenerate new hairs. Apparently the loss of the hair roots stimulates such growth. In this study it took approximately 12 to 14 days for these new hairs to reach the surface of the skin. An additional three to four weeks were then required for the hair to reach approximate maturity. It will be noticed that in all cases the bluish unprime condition of the skin appeared several days before the new hair protruded. This shows that the pigments, or the substances from which the hair shaft is made, are concentrated in the roots at the very beginning of hair growth. It also lends further support to the statements made by Gunn (*op. cit.*) and Hadwen (1934) that primeness of the skin is dependent on the growing condition of the hair rather than on environmental factors.

Experiment No. 4.—This was a check test on hare 184 and was run exactly as for hares 149 and 178. Identical results were obtained as those found in Experiment 3.

Experiment No. 5 (hare 49 exhibiting retention of summer pelage).—An unusual opportunity for studying abnormal pelage conditions was presented by hare 49. This animal failed to exhibit any color change beyond Phase 4 during the winter of 1940–41. That is,

she retained her summer pelage throughout the winter except for incomplete whitening of the ears and portions of the hind feet, legs and lower thigh, and breast regions (fig. 4). [This case becomes the more interesting in the light of Lyman's work. He terminated the winter pelage change at approximately this stage by increasing the daily amount of illumination. Hare 49, however, did so even though the light conditions were the same for her as for all the others that exhibited normal pelage changes.] It was therefore interesting to speculate, as a result of data obtained in Experiment 3, as to just what type of pelage would develop on this hare if portions of her body were plucked.

January 29, 1941.—Area 1 was plucked bare on the right side of the body. There was no sign of white hairs of any kind on this area. The bases of the existing hairs were light in color, indicating primeness of the skin.

February 7.—There was still no growth on the plucked area but it was bluer in color, indicating that unprimeness had set in.

February 14.—New brown hair one millimeter in length was now visible on Area 1. As yet there appeared to be no white hair mixed with this new growth. Area 2 was now plucked bare; no new growth was present.

February 21.—The subject had by this time attained an early Phase 4 with the white extending slightly up the breast, thighs, and lower abdominal region. The white hairs were much less abundant, however, than normal. Many of the summer pile and guard hairs were retained although they were now noticeably fewer in number all over the body despite the absence of white pile and guard hairs on the body proper. The new hair on Area 1 was now about half grown and predominantly brown with only a few interspersed white hairs. The hair in Area 2 was now one millimeter long and appeared very dark but apparently less abundant than the surrounding pelage. Area 3 was now plucked; no new hair was evident.

March 1.—The hair on Area 1 was almost completely grown out to summer hair. That on Area 3 was just starting to protrude. Area 4 was now plucked; no new hair present.

March 11.—Area 1 was now completely grown out to summer hair. That on Area 2 was about half-grown whereas there was still no growth on Area 3, but the skin was very blue, thick and rather warty. The plucking of Area 5 showed that the new summer hair had still not begun to appear on the body.

March 30.—All plucked areas were now grown in to summer hair. The back was much darker than the lower region. There was still no new growth of hair present next to the skin when Area 6 was plucked. Experiment terminated.

Results of Experiment 5.—The results of this experiment are not particularly enlightening. It was unfortunate that it was not begun earlier, but the incomplete pelage change had not been anticipated. Had the hair on some areas of the body been plucked in early December the new hair may possibly have been white. Hares 178 and 184 also grew brown hair on those areas plucked in the latter part of January whereas the regrowth of hair on areas plucked prior to that time was white. The experiment shows, however, that despite the apparent lack of a complete pelage change in this individual, she was nevertheless able to grow new hair when needed.

Hadwen (1929) says that by spring the white hairs have become attenuate at their bases and break off readily. Actually, the lower portion of the white hair is noticeably attenuate even before the new hair reaches full development He noted in 1934 that the white hairs were frequently shed in the spring with the root intact. There is no question but that the white hair is lost through some type of a molt during the vernal color change. Judging from the rapidity of the change at this time in some animals and from the raggedness of the coat, it appears that much of the white hair does break off. Certainly, large quantities of the white hair were lost before it was completely replaced by a new growth of brown hair. The remaining white hair was always much longer than the brown hair on the areas that had lost the white guard and pile hairs. Even though these hairs may break off, it appeared that the rest of the hair was eventually shed, too. After the guard hair was shed, the animals assumed either a light gray-brown appearance, cinnamon color.

or rufous-rusty hue. This was due to the undercoat becoming visible. By May the new brown pile hairs began to assume their normal length and color and the tips began to appear washed with black, especially over the ridge of the back. This is the normal color of the summer hair. It is often June or even July in some cases before this condition of hair color has covered the whole body.

If all the hair were plucked from an area early in April, new, dense, fine, brown hair was visible on the surface of the skin. These seemed more numerous than new guard and pile hairs combined would require for replacement. Consequently, it appears that the undercoat is also replaced during the early summer.

THE MONOSEASONAL THEORY OF HAIR GROWTH

During the observations on color changes in this species certain points appeared significant. A number of these points have been noted by other authors, but a different interpretation is here placed on some of them.

One point is that although the ears are nearly naked, especially on the inside, during the summer months, they are white and heavily furred in the winter. It appears, therefore, that the skin of the ears contains two types of hair roots, one set that begins to grow in late fall and another that grows in the spring. Otherwise, if the hair roots are all the same, a large part of them remain dormant throughout the summer. Either of these conditions is possible genetically. Close observation in the fall showed that the new hairs that grew in on the ears appeared white to the human eye from the time they were first noticeable. The ear itself became white due to the abundant new white hairs over-shadowing the brown ones that were shedding. When the ear became completely white, few brown hairs remained.

If such a condition of the hair roots exists on the ears, it seems logical to assume that a similar condition may well exist over the rest of the body also. If this were true, one should be able to find the new white hairs appearing next to the skin long before the animal appeared white, or even partially so, to a casual observer. The discovery of the presence of such hairs has already been discussed.

Allen (1894) noticed their presence in a series of study skins collected at chosen intervals of color change. The same condition was discovered in this study independently, however, on live specimens and the growth of these hairs was observed to maturity. Allen's original paper was not seen until after the present research on the subject was practically complete. Consequently, it was interesting to note the striking similarity between the two sets of data. It was found that these short white hairs were universally present, early in the color change, over the entire body on all specimens studied.

Grange (1932) also confirmed Allen's work [as did Lyman, 1943], but regarding Grange's work Hadwen (1934) says: "If Grange's explanation is correct, that a new growth of white tipped hairs takes place in the autumn after the moult, it implies that the new hairs start growing as white hairs, and if so, we should see pure white underfur prior to the outward whitening of the animals."

This is in part what we do find only Hadwen did not recognize its significance, for he says earlier in this same paper: "One of the captured hares (No. 32) died of pneumonia. This animal had an abnormal coat. There were a large number of short degenerating white hairs near the skin. These hairs had whitened before they had completed their growth and it is possible that they ceased growing when the hare became ill."

This is the natural condition of the new white hairs when they first appear as observed during this study in approximately 30 live animals of various ages and conditions of health throughout one complete autumnal color change. Such a condition does not imply a pure white underfur as Hadwen supposed. Instead, the white hairs are definitely in the minority, but nevertheless visible, intermingled with the plumbeous and tawny underfur. The progressive growth of these small white hairs into mature pile and guard hairs is easily followed.

POSSIBLE FACTORS INSTIGATING THE PELAGE CHANGES

An explanation of the manner in which the pelage change takes place does not necessarily explain the cause of the change. The possible factor or factors instigating the molt are here considered.

Climatic.—Grange (1932) believes that the changes of pelage are not correlated directly with *immediate* climatic conditions, but rather with the *average* climatic conditions.

[*Light.*—Lyman (1943) effectively proved that it is the amount of daily illumination hitting the hares' eyes that instigates and at least partly controls the pelage changes. He also gives the results of experiments showing the effect of internal secretions on the pelage changes.]

Heredity.—Observations during this study tend to indicate that the conditions bringing about the pelage changes are in part peculiar to each animal. Whether these individual peculiarities are inherent, or dependent on internal secretions as suggested by Hadwen (1934), or upon physical fitness is not yet known. There are a few indications that it is inherent, as, for example, the consistency of the changes as to time, despite external conditions, and the incomplete winter coats of female 47 and her offspring.

Also, it appears that if one hare turns white early in the season one year it will do likewise the next or *vice versa*, but this is based on only two years of observation. It is difficult to decide whether to consider this inherent or peculiar to an individual because of its physical condition. Hares 55 and 49, both females, may be cited as examples. The history of the latter indicates that some physiological phenomenon affects or may affect pelage changes and color. Hare 55 was the first to begin turning white in the fall of 1939. Although she did not require a shorter time to complete the change than some of the others, she did finish it much earlier, November 21. No other hare reached a complete Phase 7 before December 1. In the fall of 1940 she was already in Phase 2 by October 1; that is, her ears, hind feet and legs were white. Again she reached Phase 7 shortly after the middle of November, far ahead of any other (Tables 1 and 2). Hare 49, on the other hand, did not begin her color change until about mid-October in 1939 and not before early November in 1940. She completed it by December 22 in 1939, but in the fall of 1940 did not progress beyond an early Phase 4 (fig. 4). With the exception of partly white hind feet and legs and a touch of white on the ears and lower portion of body, she remained in complete summer pelage throughout the winter. Her environmental conditions remained the same during the two winters and they were also the same as for the other hares. Other examples of equal or similar schedules of autumnal pelage changes in hares over a two-year period may be found in Tables 1 and 2. Note the similarity with which ♀ 4 and ♂ 61 began their respective changes during the two autumns. This may be a coincidence, but it may also show that some hares follow a fairly close schedule from one year to another.

Physiological.—There were no means of determining what factor or factors prevented the normal pelage changes from taking place in hare 49. She gave birth to her fourth litter (5 young) on August 15 and nursed three of them for eight weeks. Although this was doubtless a drain on her physically, she remained in good flesh. She was a large animal (1787 grams on December 13) and at all times throughout the winter appeared in good health. Three other hares that gave birth to fourth litters during August exhibited normal pelage changes.

A few immature hares tended to support the theory that the time of change depends on internal secretions or general physical condition. Those that were in a run-down condition caused by coccidiosis were much slower than healthy individuals to begin, as well as to attain, their pelage changes. Hares 161 and 166 both shed their summer pile and guard hair before the new winter hair had an opportunity to mature.

COMPARISON OF PRESENT OBSERVATIONS WITH FORMERLY PUBLISHED DATA

In light of the present study it appears that a comparison of data is needed to settle some of the conflicting issues.

The Fate of the Summer Pelage.—If it were true that the hair turned white due to lengthening and blanching, the pile and guard hairs on those parts that have become white should always be longer than the hair on the areas still brown. This is not true for it was shown conclusively in Experiment 1 (figs. 15 and 16) that all white hairs are at first shorter than the surrounding summer pelage. The white hairs continue to grow and soon surpasses the brown hair in length. If the hair turned white due to lengthening and blanching of the summer hair, as suggested by Richardson, the brown hair would have to shrink first or break off before becoming white in order to account for the universal presence of these shorter white hairs at this time.

By the time the new white pile hairs are approximately as long as the brown pile hairs, the latter are seen to be unquestionably fewer in number and more scattered on the white area than on those areas still completely brown. Where the coat is still predominantly brown, the brown hairs are still longer than the white.

Hadwen (1934) favored the theory of blanching of the brown pelage because in his experiments on clipping hares he believed that the brown hairs turned white because they could be identified by their cut ends and also by dye on the cut ends of the hair on certain animals used in his experiments. Based on the results of Experiment 1 of this study it is logical to assume that those hairs that he identified by their cut ends were actually early new-grown white hairs that were long enough at the time of clipping to have had their tips cut off when the bases of the brown pile hairs were cut. The hare that he clipped was so treated on September 16, at which time he reported it as having white feet and ears and to be white along the flank and part way up the hip and shoulders. This would correspond to Phase 4 described above. It was there shown that by that time the new white hairs were abundant over the whole body but were so short that they could not be seen without parting the hair. They were certainly long enough by that time, however, to be affected by clipping the coat. Had the white hairs in Experiment 1 of this study been the result of blanching as reported by Hadwen for his similar experiment, then they should have had 100 percent cut ends rather than no cut ends at all. He reportedly found 100 percent cut ends in his clipping experiments nos. 1 and 5, but this was apparently because the areas were not clipped until the new hair was sufficiently long to be entirely affected by clipping.

In his experiments with dyes, Hadwen (1934) found the outer hair lost its dye but the undercoat did not. He used this fact as a further basis for stating that the pile hairs blanched, the loss of the dye indicating a change in the physical make-up of the hair itself. On the other hand, the undercoat does not change color or physical make-up and he found that it retained the dye as well as did pile hairs dyed after they were white.

Although these experiments were not checked in this study, it appears that the dye did not disappear from the pile hairs but that the dyed summer pile hairs were actually shed. Using similar reasoning the dye remained on the undercoat because, as has already been stated, it is not believed to shed in the fall.

FACTORS AFFECTING THE PELAGE CHANGES

Destructive alterations.—The theory advanced that the alteration of color is a progressive destructive change, overlooks the fact that even a complete growth of new white hair replacing the brown would require, and result in, a progressive change in color, for growing hair does not attain its maximum length all at once. Nor is the brown summer hair shed simultaneously. The progressive change is due to the blend resulting as the white hairs gradually equal the brown hairs in length and surpass them in abundance as the latter are shed. If the pile and guard hair of this species blanched through a destructive alteration, one might easily assume that the undercoat should do likewise. This did not happen with any of the animals observed in this study and there appears to be no record in the literature of such blanching.

Albinism.—The term "albino" when used in reference to the snowshoe hare is confused with "white." The albinotic gene in heredity is not one which determines the specific

color but one that prevents the expression of any color. In other words, it is a quantitative quality rather than a qualitative one. If an animal carries the gene for albinism in the homozygous state it is impossible for the animal to show color despite the fact that it actually carries the gene for some color (Snyder, 1935). The white hair in variable or multicolored animals is not true albino hair, but is the result of one of an entirely different set of genes that expresses the "spotting" character. This character may be expressed in several different ways such as silvering, a star on the forehead (blaze), belted, belly spot, and others. This is also no doubt the case in the snowshoe hare. Were the white hairs true albinotics it would be impossible for the central portion of the shaft to be pigmented. Also if the hares were able to express true albinism in the pile and guard hairs their underfur and all other hair would have to remain colorless throughout their lifetime. The factors for color causing the multiple coloration in many of our domestic rabbits are well worked out genetically and are known to be multiple allelomorphs (Snyder, 1935). Some sort of multiple factors must certainly regulate the coat color in hares also. The cyclic shedding may well be one separate allelomorph whereas other allelomorphs may be responsible for the variation in pigment deposition. There is a good example in mice of a genetic tendency toward cyclic shedding. It is a dominant character known as "naked" (Gordon, 1850). This character is expressed by the animal having hair on its head and mid-body region at one period with the rest of the body hairless, whereas at another period the former haired area will be naked and the naked area fully haired.

Physiological.—From a genetic viewpoint the agouti pattern of hair color is dependent on physiological phenomena for its expression and arrangement but must be present as a genetic character before the physiological conditions can bring about the effect. Despite the presence of the genetic character, however, it is entirely possible for physiological phenomena to prevent the expression of the character. An excellent example of such a condition was exhibited by hare 49 already referred to (Experiment 5 of this study), which turned white in the winter of 1939 but failed to make her normal pelage changes in the winter of 1940.

Pigment deposition.—As already mentioned, Hadwen (1934) has pointed out that the white hair in hares does contain pigment. Binocular examination shows the tip of the white hair to appear pigmented and many of them have their bases so pigmented that that portion appears noticeably darker even to the naked eye. But, they do not necessarily remain so. This condition is very noticeable just before the hairs reach a length equal to that of the remaining summer hair. As the hair reaches maturity the basal pigmented portion is greatly decreased. In this respect Gunn says that the density of pigmentation is probably the major factor determining the amount of blanching in a given hair-shaft. He points out that the snowshoe hare occupies an intermediate position in showing the development of this feature, since the blanching process takes place in such a manner as to leave the middle portion of the hair-shaft the last to become white. This species does not show the priming process to so great an extent, according to Gunn, as do the jackrabbits, in which the process does not stop until the fur hairs are completely blanched.

Based on only external observations on this species, the writer does not feel that the color of the hair is effected primarily by the amount of pigment the root contains. If it were thus effected, the distal end of the shaft ought to be pigmented for in an unprime skin the hair roots are darkest in the earliest period of growth and could normally be thought of as containing their greatest amount of pigment at that time. Instead, the distal half of the mature winter hair is white, with the exception of the extreme tip, and this is followed in turn by the dark quarter and then the light colored proximal portion. It appears that the greatest amount of pigment production by the root took place midway in the growth cycle of the hair. On this basis the explanation of the pigmented hair roots in an unprime skin and unpigmented ones in prime skins might possibly mean that part of this pigment is due to the concentration in the root of organic salts to be used in developing the hair-shaft. Such salts would appear even before the new hair begins to grow. The pigment granules, instead of being present throughout growth, according to this hypothesis would form mid-

way in the growth period. By the time the hair-shaft reaches maturity the organic material in the root has all been utilized in its construction. The root itself, consequently, now becomes transparent because the single thickness of the cell walls alone are insufficient to block light rays. It is felt that the black tip on each hair-shaft is due to the compactness of the cells in that area.

The theories of Hadwen (1929 and 1934) or Gunn (1932a and 1932b) concerning the internal pigmentation and condition of the hair and hair roots as the principal causes for color in the snowshoe hare are not questioned. No research on this point was undertaken in this study. [See Lyman (1943) for the most recent work on this phase of the problem.] There is no doubt, however, that irrespective of how the white color of the hair is attained, the white winter hair is of a new growth as postulated by Allen (1894) and Grange (1932). The white hair replaces the brown pile and guard hairs that are shed soon after the corresponding new hair reaches approximate maturity.

SUMMARY

The results of the present study agree closely with those of previous workers regarding the manner of the pelage changes but an attempt has here been made to establish seven distinct steps, or phases, through which the process normally progresses during both the autumnal and the vernal molts. The process during the vernal molt is exactly the reverse of that which takes place during the autumnal molt.

Data showed that in the latitude of Maine pelage changes seem to be controlled more by the time of year than by the environmental conditions. [Confirmed by Lyman, 1943.] The beginning of the autumnal change first becomes noticeable late in September and is usually completed by the first of the year. The time required to complete this molt varied from 52 to 107 days with an average of 74 days for the two seasons. Females averaged slightly less time than males to complete the change. Young hares required eleven days more to complete the change than did the adults.

The vernal change begins early in March and is about 90 percent complete within 50 days. The average time required for the complete change was 71.8 days. Females again, with occasional exceptions, required less time to molt than did males and the process occurred somewhat earlier in the season.

Experiments in clipping and plucking showed that the snowshoe hare is capable of regenerating new hair at any time in an area where it is lost, but the growth must be instigated by the loss of the old hair roots unless the animal's hair is already in the process of change. The new hair so grown always has the same characteristics as the rest of the pelage or those toward which the pelage is tending at the time the new hair begins to grow.

As a result of the study the *monoseasonal theory* of hair growth is advanced for this species—that snowshoe hares have two different sets of hair roots each with their respective active and dormant periods of activity. One set gives rise to the vernal brown pelage and the other to the autumnal white pelage and heavier underfur.

It is believed that the factors instigating the pelage changes are complex and that heredity, physiology, and perhaps environmental factors, [including amount of light—Lyman, 1943] all play a part, any one of which, if abnormal, can effectively prevent a normal pelage change.

The underfur appears to be augmented during the autumnal molt and to be completely replaced during the vernal molt.

The writer believes that the experiments herein recorded show that, irrespective of how the white color of the hair is attained, the winter pelage constitutes a new growth. This replaces the brown pile and guard hairs that are shed soon after the corresponding new hair reaches approximate maturity.

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Maine Cooperative Wildlife Research Unit, University of Maine, Orono, Maine.

THE EXTERNAL GENITALIA AND PERFUME GLAND IN *ARCTICTIS BINTURONG*

By H. Elizabeth Story

Several adult specimens of the East Indian civet, *Arctictis binturong*, were recently presented by the Chicago Zoological Society to the Chicago Natural History Museum. A pair was selected to be especially embalmed for future thorough anatomical study. The external genitalia from two other individuals were also preserved.

When the sex of these specimens was determined, the external genitalia and scent glands were compared with Pocock's (1915) figures and description. His drawings, admittedly somewhat diagrammatic, prove to be extremely misleading. Conspicuous differences in the actual appearance of these animals from Pocock's published figures make it worthwhile to submit the following observations and illustrations. Two juvenile *Arctictis*, already in our collection, were also examined. The reproductive organs of a young female *Arctictis binturong* are briefly described and figured by Albertina Carlsson (1920). In her immature specimen the scent glands lie on each side of the vulva, exactly as in her young female specimen of *Paradoxurus hermaphroditus*. Carlsson speculates that the glands might not yet be in their final position. Comparison of the adult and juvenile specimens here reported shows that no postnatal shift in position occurs.

The sac-like anal glands, described by Garrod (1878) in a male specimen, are present in both sexes. The short wide ducts of these glands open on either side of the anus and are visible to the unaided eye.

In the adult male binturongs (CNHM 53763, 53747) the penis is remarkable for its well-defined collar-like prepuce (fig. 1, a). In this respect the binturong resembles the giant panda, of which a comprehensive anatomical description is in progress at this museum. The urethra opens at the base of the conical glans penis. The prepuce is less prominent in the juvenile male (CNHM 51375). This suggests the possibility that Pocock's specimen was immature. The perfume gland, buried in a thick layer of adipose tissue, is indicated externally by the ovoid swelling of the integument, or labia, extending from the penis to the scrotum (Plate 1). The naked longitudinal fossa into which the numerous ducts of the perfume gland open, has a distinct median raphe running from the prepuce to the scrotum. In the juvenile specimen the raphe occurs in the posterior half of the fossa. Pocock found this partition only in the posterior end of the fossa, and his illustration gives the impression that a pouch is present. Actually the rounded labia of the gland are separated by a simple concavity, which varies in depth according to the degree of labial divarication. A shallow marginal indentation opposite the root of the raphe marks the end of the glandular region and the beginning of the scrotum. The texture of the integument becomes less porous. The scrotum continues posteriorly for 27.5 mm, in the same plane as the gland. The anus, hidden ventrally by the scrotum, is situated dorsad of the posterior extremity of the perfume gland (fig. 1, b). The bilaterally symmetrical glands extend anteriorly to the level of the prepuce, but the anterior tips do not unite.

Laterally the gland is crossed by the spermatic cord. Posterodorsally the glands fuse, and project a few millimeters beyond the scrotum.

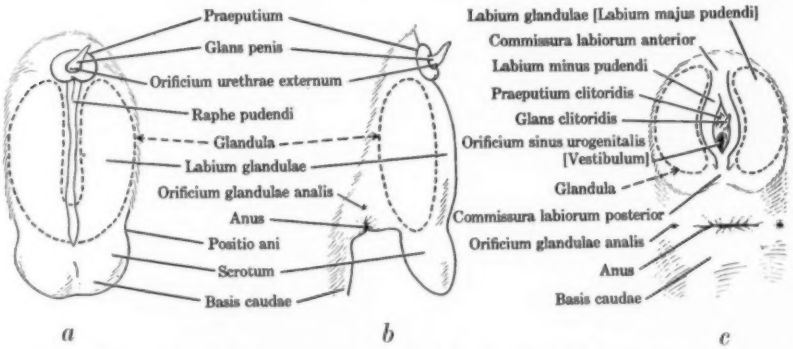

FIG. 1. Diagram to show the topographical relationships of the external genitalia and perfume gland (in dotted lines) in the adult *Arctictis binturong: a*, male, ventral view; *b*, male, side view; *c*, female, ventral view. Appx. $\frac{3}{5}$ natural size.

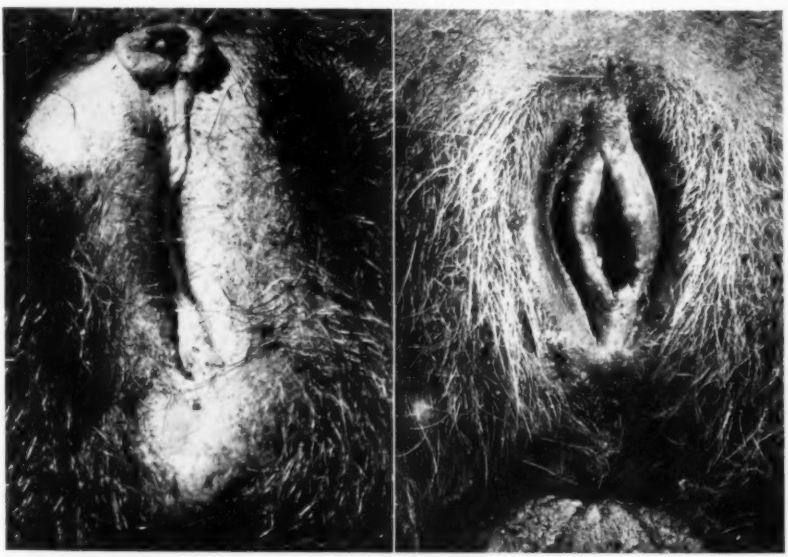

PLATE 1

Unretouched photographs of the external genitalia in adult male (CNHM 53763) and female (CNHM 53764) *Arctictis binturong*.

In the two adult and in the juvenile female *Arctictis* (CNHM 53764, 53748 and 50068 respectively), the vulva lies in the center of the glandular area (Plate 1).

Pocock states that the vulva lies in front of the gland, consequently omitting the vulva entirely in his figure. The minor pudendal labia occupy the longitudinal fossa between the large glandular labia [labia majora pudendae of human anatomy?], and surround the clitoris and the opening of the urogenital sinus (fig. 1, c). The minor labia are not perforated by ducts from the perfume gland. Considerably flatter than in the male, the gland extends anteriorly beyond the clitoris to the level of the anterior labial commissure, posteriorly to the dorsal margin of the vestibule. The fat covering the gland laterally bulges the integument forming the major labia. Dorsad of the posterior labial commissure the major labia contain no glandular tissue. Pocock appears to confuse the integument of the major labia with the gland itself. Medially a sheet of connective tissue is all that separates the gland proper from the skin; the reservoirs of the gland open directly through enlarged cutaneous pores in the naked longitudinal fossa. The position of the gland in the pudendal rather than perineal region nullifies Pocock's remarks (1915, p. 411) anent the gradation of the situation of the gland in the female paradoxurines. The raphe indicated in his figure of the female *Arctictis* (fig. 8B, p. 406) is nonexistent. He failed to recognize the labia of the vulva in the "low median ridge of skin" designated in his figure. The true position of the vulva brings out a similarity to his female *Paradoxurus* (fig. 6D, p. 402).

Generalizations upon these forms cannot safely be made at present. It may be pointed out that Gregory and Hellman (1939) refer to Pocock's papers without questioning his descriptions or figures. The problems arising from the confused state of the literature on the civets will remain unsolved until more material becomes available for thorough and accurate investigation.

SUMMARY

The external genitalia and scent gland of adult specimens of *Arctictis binturong* differ from Pocock's description in the following respects:

1. Presence in the male of a prominent collar-like prepuce, and a distinct median raphe in the glandular fossa, running from the prepuce to the scrotum.

2. Position of the scent gland in the female, surrounding the vulva; the raphe indicated by Pocock is not present.

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Division of Anatomy, Chicago Natural History Museum, Chicago, Illinois.

A STUDY OF THE *CLETHRIONOMYS DAWSONI* GROUP OF RED-BACKED MICE

By Robert T. Orr

During the past several years the California Academy of Sciences has received a number of specimens of mammals, including a representative series of red-backed mice of the *Clethrionomys dawsoni* group, taken by Mr. Ben B. Watson in the Cape Yakataga region of southeastern Alaska. These red-backed mice have proven, in the writer's opinion, sufficiently different from the heretofore known races of *dawsoni* to merit subspecific recognition. Furthermore, on reviewing the species as a whole, another previously unrecognized geographic variant occurring farther to the south of the Yakataga region was discovered. During the course of this study specimens representing all of the known subspecific forms of *dawsoni* as well as allied Nearctic and Palearctic species of *Clethrionomys* were examined.

Evotomys [*Clethrionomys*] *dawsoni* was first described by Merriam (1888, p. 650) on the basis of a single specimen in the Museum of Geological and Natural History Survey of Canada, collected by Dr. George M. Dawson along the Finlayson River, a northern tributary to the Liard River, Northwest Territory, lat. 61° 30′ N., long. 129° 30′ W. Bailey (1897), in his revision of the genus *Evotomys*, had available 61 specimens representing the species *dawsoni*. Twenty-three of these, from northern Alaska and eastward in northern Canada, were considered as belonging to the Palearctic species *Evotomys rutilus*. The remaining 38 specimens from five scattered localities in southeastern Alaska, southeastern Yukon and the southwestern part of the Northwest Territory were allocated to *Evotomys dawsoni*. This peculiar separation of these Alaskan red-backed mice into two species was apparently, in part, in conformity with the previous strongly expressed and widely accepted view of Dr. Elliott Coues (1877, pp. 136–141) concerning the circumpolar distribution of *rutilus*. In 1898 Miller (p. 364) described as new *Evotomys alascensis* based upon 21 specimens, 19 of them from St. Michaels, Norton Sound (the type locality), and 2 from Fort Yukon. These, presumably, were some of the same specimens ascribed by Bailey (*op. cit.*) the previous year to *rutilus*. Comment is made upon the close relationship between *alascensis* and *rutilus*, the latter being restricted by Miller to the Palearctic. No mention is made of *dawsoni*. Later Osgood (1904, p. 34) clearly showed that *alascensis* was indistinguishable from *dawsoni*, hence *alascensis* was reduced to a synonym of *dawsoni*.

Merriam (1900) described *Evotomys orca* from Orca, Prince William Sound, based upon seven specimens obtained by the Harriman Expedition to Alaska. In the original description of *orca* (*op. cit.*, p. 24) comment is made regarding its resemblance to *dawsoni*. Heller (1910, p. 339) later considered it as a subspecies of *dawsoni* and in the same paper described *Evotomys dawsoni insularis* from Hawkins and Hinchinbrook islands in Prince William Sound. Since this time little inquiry has been made into the systematic relationships of the various members of the *dawsoni* group. Miller (1912 and 1924) lists the known

forms, their type localities and the range of the race *dawsoni*. *Evotomys orca* is treated as a separate species. This same arrangement is followed by Hinton (1926) and Ellerman (1941). Davis (1939, p. 306), in considering the North American groups belonging to the genus *Clethrionomys*, accords *orca* subspecific status as a member of the species *dawsoni*, a view similarly held by the present writer.

Clethrionomys dawsoni, as a species, occurs throughout most of Alaska and eastward across northern Canada to the western shore of Hudson's Bay. Over this relatively extensive territory it exhibits a fairly marked uniformity in characters, except in the coastal region of southeastern Alaska where several recognizable geographic races occur. In the latter region certain environmental factors appear to have contributed to the subspecific differentiation that is apparent along a comparatively narrow coastal strip. Significant perhaps is the presence of high coastal ranges that act as a barrier separating the inland fauna from that of the immediate coast and are largely responsible for the decided climatic differences to be observed between interior southeastern Alaska and northern British Columbia to the east and the coastal area to the west. The presence of what may be termed "biological islands" resulting from the combination of these mountain barriers to the eastward, the Pacific Ocean on the west and numerous large glaciers extending from the mountains to the sea also are contributing factors effecting the isolation of animal populations. True islands, separated from each other and the mainland by deep water channels in which the currents are exceedingly swift, likewise, are present in numbers. At least one race of *Clethrionomys dawsoni* is strictly insular and further exploration, especially in the region of Prince William Sound, may reveal the existence of additional island forms.

Careful examination has been made of the several species of *Clethrionomys* whose ranges are closely complementary to that of *dawsoni*. These include principally *gapperi* in the Nearctic and *rutilus* and *rufocanus* in the Palearctic. The conclusions reached by the writer agree closely with those of Davis (*op. cit.*, pp. 305–308) who was the first to indicate clearly the relationships of various members of the genus *Clethrionomys* occurring in this hemisphere. In North America the range of *dawsoni* closely approaches that of the more southern species *gapperi* in a number of localities but, so far as the writer knows, the two have not been taken together. It is highly probable that in certain localities their ranges do overlap. This, however, is not indicative of any close relationship, being somewhat comparable to the situation existing in the Old World between *rutilus* and *glareolus*. On the contrary the two species are widely divergent in several fundamental respects. In *dawsoni*, except in an occasional extremely old individual, the lateral postpalatal bridges are incomplete. This is not true in the case of *gapperi* in which even half-grown young possess complete postpalatal bridges so that the posterior margin of the plate forms a solid shelf. Furthermore, *dawsoni* is readily distinguishable from *gapperi* by its decidedly stouter and more heavily haired tail as well as by its proportionately larger hind feet. The enamel pattern of the molariform teeth is essentially the same in both species.

The same general characters separating *Clethrionomys dawsoni* from *C. gapperi*

serve also to distinguish it from *Clethrionomys phaeus* and *C. wrangeli* which occur in southeastern Alaska, only a short way to the south of *Clethrionomys dawsoni glacialis*. In this connection it may be mentioned that these two forms, *phaeus* and *wrangeli*, definitely appear to belong to the *gapperi* group as previously indicated by Davis (*op. cit.*, p. 306). Neither is there any close relationship between *dawsoni* and the various members of the *Clethrionomys californicus* group of western North America, including the forms *californicus, mazama* and *obscurus*. All of the latter are distinguished by relatively heavy dentition as well as by the more simplified enamel pattern of M^3 and M_1 in which the number of salient and re-entrant angles tends to be reduced in adults. Likewise, in these forms the postpalatal bridges are complete and the posterior margin of the palatal shelf tends to extend posteriorly as a thin triangular projection with the apex directed backward. The pterygoid processes are much heavier than in either *dawsoni* or *gapperi*. Externally they much resemble *gapperi* in appearance, possessing, like most members of that species, a long tail in contrast to the short stocky tail so characteristic of *dawsoni*.

Cranially *Clethrionomys dawsoni* bears a close resemblance to *C. rutilus* of the Palearctic. The probable relationship between these two species has been suggested by Hinton (1926, p. 216). The two species are essentially alike as regards the enamel pattern of the molariform teeth and the presence of incomplete postpalatal bridges. Externally, however, *rutilus* exhibits an even shorter, stouter tail and denser, longer pelage. Specimens examined, representing *C. rutilus*, from northern Manchuria and from Yakutsk in eastern Siberia, are decidedly paler in color than any representatives of *dawsoni* available from North America.

Clethrionomys albiventer, an insular form from St. Lawrence Island in Bering Sea, occurs geographically between the ranges of *C. dawsoni* of the New World and *C. rutilus* of the Old World. It appears specifically distinct from either of these species, as stated by Hall and Gilmore (1932, p. 399), although obviously it is a member of the same group to which they belong. This is clearly indicated by its incomplete postpalatal formation, dentition, heavy pelage and short, stocky tail. While known from only three specimens, these all agree in their uniformly large size which is unequalled by members of any of the known races of *dawsoni* or *rutilus*. *C. albiventer*, furthermore, differs from *dawsoni* in its decidedly larger auditory bullae and paler coloration.

Clethrionomys dawsoni differs from *C. rufocanus* of Asia as markedly as it does from members of the *californicus* group in western North America. All specimens of *rufocanus* examined are distinguishable by a reduction in the number of salient and re-entrant angles in M^3, a complete postpalatal bridge, at least in adults, and by a relatively long, slender tail.

A total of 247 specimens of *Clethrionomys dawsoni* were examined in connection with the present study, in addition to numerous specimens representing related species belonging to this genus. For the loan of certain study skins and skulls, which contributed materially to the completion of this study, the writer wishes to thank Dr. Seth B. Benson of the University of California Museum of Vertebrate Zoology, Dr. Hartley H. T. Jackson of the United States Fish and Wildlife

Service, Dr. W. J. Breckenridge of the University of Minnesota Museum of Natural History and Mr. Anatole S. Loukashkin. The author is indebted to Dr. G. Dallas Hanna of the California Academy of Sciences for interesting Mr. Ben B. Watson of Cape Yakataga, Alaska, in the securing of mammal specimens from that region for scientific study and to the latter especially for the considerable effort he made in this endeavor.

Clethrionomys dawsoni dawsoni (Merriam)

Evotomys dawsoni Merriam (1888, p. 650), original description.
Evotomys alascensis Miller (1898, p. 364).

Type locality.—Finlayson River, one of the northern sources of the Laird River, lat. 61° 30′ N., long. 129° 30′ W., altitude 3,000 feet, Yukon, Canada.

Range.—Throughout most of the mainland of Alaska, except for a narrow coastal strip in the southeastern part, eastward across northern Canada to the western shore of Hudson's Bay, at least in northern Manitoba.

Diagnosis.—Size medium, insofar as total length is concerned; hind foot moderately long; in general coloration, palest of known races of *dawsoni*; top of tail reddish, somewhat similar to back; tips of ventral guard hairs varying from whitish to moderately buffy; skull narrow across zygomata; nasals long; braincase proportionately narrow.

Measurements.—The average and extreme measurements in millimeters of 10 adults from Atlin, British Columbia, are as follows: Total length, 140.4 (130–151); tail, 35.8 (31–44); hind foot, 19.8 (19–21); ear, 12.5 (10–14); condylobasal length (9 averaged), 24.2 (23.4–24.8); zygomatic breadth, 13.4 (12.4–14.1); length of nasals, 7.6 (7.3–8.0); breadth of braincase superior to external auditory meatus (9 averaged), 10.1 (9.7–10.7); crown length of maxillary tooth row, 4.9 (4.7–5.0).

Remarks.—The range of the race *dawsoni* includes a vast area in northern North America, extending longitudinally a distance of nearly 2400 miles from the shores of Bering Sea in the vicinity of Norton Sound eastward to the region of Hudson Bay. The northern extremes of its range parallel the northern limit of trees along the lower course of the Mackenzie River near its entrance into the Arctic Ocean according to Preble (1908, p. 180). The species ranges southward nearly 700 miles to southeastern Alaska in the west and to northern Manitoba in the east.

Throughout this extensive territory it appears to exhibit a high degree of racial uniformity although in certain localities a seemingly unusual amount of individual variation is to be found in the color of adult specimens of comparable pelage. This is well shown by a series of 83 study skins from the Atlin region of British Columbia, taken between June and October. While considerable variation occurs in different individuals with respect to the intensity of red pigmentation dorsally, the tips of the ventral guard hairs show an even greater range in color. This varies from pure white on some specimens to a relatively deep buff in others, not quite equalling, however, the deep buff so characteristic of the tips of the ventral guard hairs of members of either *glacialis* or *watsoni*.

The type of *dawsoni* has not been seen by the writer. Three specimens in the United States Biological Survey Collection, taken by Charles Sheldon (*cf.* Sheldon, 1925, p. 263) at Ross Lake, about 85 miles northwest of the type locality, were examined as well as three specimens in the same collection from the Russell Mountains, near the Forks of the Macmillan River, farther to the northwest. These six individuals, all subadults, tend to be as dark in color as the darkest of the Atlin series.

A single skin and skull from Nonala, 80 miles north of Churchill, Manitoba, recorded by Breckenridge (1936, p. 62), was examined. This specimen, taken approximately 1200 miles east of the type locality of *dawsoni* is identical in color with certain Atlin taken skins. Cranially it also agrees with typical *dawsoni* in the possession of a proportionately narrow skull and long nasals. Eight specimens from along the Savage River in the Mt. McKinley

District of Alaska agree in both cranial and color characters with the Atlin series and, like the latter, exhibit a considerable range of variation in color.

Osgood (1904, p. 34) considered *Evotomys alascensis* as a synonym of *Evotomys dawsoni* and indicated that specimens from the vicinity of Norton Sound were not recognizably different from those from the Upper Yukon, assuming the latter to be typical *dawsoni*, except for differences obviously falling within the range of individual variation. Only one specimen, an adult male (Mus. Vert. Zool. no. 51220), from this region, taken 10 miles south of Unalakleet, was examined by the writer. In color it is decidedly pale but is equalled by the palest specimen in the Academy's series from Atlin, British Columbia. Cranially it resembles typical *dawsoni* except for the fact that the nasals are very short, measuring only 6.8 mm in length. This feature, however, would not appear to be typical of the known specimens from Norton Sound as Miller (1898) in his original description of *alascensis* characterizes it, in part, by the possession of long nasals, those of the type measuring 8 mm.

Only four specimens, two of them being skins without skulls, were available from the Kenai Peninsula. Although one might reasonably expect, upon geographic grounds, that they would be more closely allied to *orca*, they agree in all characters with *dawsoni*.

Specimens examined.—A total of 113 from the following localities: **Alaska:** Yukon River, 28 mi. above Circle, 3 (coll. Univ. Calif. Mus. Vert. Zool.); Cascade Creek, 10 mi. S. Unalakleet, Norton Sound, 1 (coll. Univ. Calif. Mus. Vert. Zool.); Fish Creek, 30 mi. N. Fairbanks, 2 (coll. Univ. Calif. Mus. Vert. Zool.); Savage River, 2,800 ft., Mt. McKinley District, 8 (coll. Univ. Calif. Mus. Vert. Zool.); Moose Camp, Kenai Peninsula, 1; Mills Creek, Kenai Peninsula, 1 (coll. Univ. Calif. Mus. Vert. Zool); Kenai River, Kenai Peninsula, 1 (coll. Univ. Calif. Mus. Vert. Zool.); near Lower Kenai Lake; Kenai Peninsula, 1. **Yukon Territory:** Forty Mile, 3 (coll. Univ. Calif. Mus. Vert. Zool.); Russell Mts., near forks Macmillan River, 3 (U. S. Nat. Mus., Biol. Surv. coll.); Ross Lake, Ross River, 3 (U. S. Nat. Mus., Biol. Surv. coll.). **British Columbia:** Atlin, 73; 10 mi. E. Atlin, 1; 12 mi. E. Atlin, 6; 15 mi. E. Atlin, 3; Junction, 4 mi. N. Telegraph Creek, 1 (coll. Univ. Calif. Mus. Vert. Zool.); Stikine River at Doch-da-on Creek, 1 (coll. Univ. Calif. Mus. Vert. Zool.). **Manitoba:** Nonala, 80 mi. N. Churchill, 1 (coll. Univ. Minn. Mus. Nat. Hist.).

Clethrionomys dawsoni glacialis, new subspecies

Type.—Adult male, skin and skull, no. 388, University of California Museum of Vertebrate Zoology; from Glacier Bay, Alaska; collected July 11, 1907, by Frank Stephens; original no. 158.

Range.—Known only from the vicinity of the type locality in southeastern Alaska.

Diagnosis.—Size large; hind foot relatively long; color darker than in *dawsoni* with red pigmentation more intense; hairs on dorsal surface of tail not blackish but similar in color to those of back; tips of ventral guard hairs deep buff; skull moderately broad across zygomata; nasals long; braincase broad.

Measurements.—The average and extreme measurements in millimeters of four adults, including the type, from Glacier Bay, Alaska, are as follows: Total length, 147.5 (144–154); tail, 36.8 (33–39); hind foot, 20.4 (20–21); ear, 13 (13–13); condylobasal length, 24.9 (24.3–25.4); zygomatic breadth, 14.1 (13.9–14.4); length of nasals, 7.7 (7.4–8.0); breadth of braincase superior to external auditory meatus, 10.5 (10.2–10.6); crown length of maxillary tooth row, 5.0 (5.0–5.1).

Remarks.—The region about Glacier Bay in coastal southeastern Alaska represents the northern end of the Sitkan faunal district, as defined by Swarth (1936, p. 60). Most mammalian species that have invaded this region since postglacial occupation began seem to have come from the east rather than from the north or the south. *Clethrionomys dawsoni* does not appear to be an exception to this general principle. The race *glacialis* shows a much closer relationship to *dawsoni* occurring to the eastward than it does to either *orca* or *watsoni* to the north. If we accept Swarth's (*op. cit.*, pp. 60–61) view that this part of southeastern Alaska was covered by ice until after the close of the Pleistocene, we may

justifiably presume that the race *glacialis* has become differentiated during this relatively short postglacial period.

Although only 5 of a total of 18 specimens examined from the region of Glacier Bay are adults, all agree uniformly in respect to the characters herein ascribed to this race. They are readily distinguishable from the numerous specimens examined representing the race *dawsoni* by their generally larger size, more intense pigmentation, especially on the tips of the ventral guard hairs, and greater cranial breadth. Even though *glacialis* bears a resemblance to *watsoni*, as regards the deep buffy coloring of the tips of the ventral guard hairs, none of the specimens seen possesses the dark dorsal body coloration and blackish color of the hairs on the dorsal surface of the tail so characteristic of the more northern coastal form.

Specimens examined.—A total of 18 (coll. Univ. Calif. Mus. Vert. Zool.) from the Glacier Bay region of southeastern Alaska, as follows: Glacier Bay, 10; Bartlett Cove, Glacier Bay, 6; Coppermine, Glacier Bay, 2.

Clethrionomys dawsoni insularis (Heller)

Evotomys dawsoni insularis Heller (1910, p. 339), original description.

Type locality.—West side Canoe Passage, Hawkins Island, Prince William Sound, Alaska.

Range.—Known only from Hawkins and Hinchinbrook islands, Prince William Sound, Alaska.

Diagnosis.—Size large; hind foot proportionately short; color comparatively pale, but hairs of back and top of tail somewhat more reddish than seen in *dawsoni*, tips of ventral guard hairs pale buffy or whitish; skull moderately broad across zygomata; nasals short; braincase of medium breadth; auditory bullae averaging larger than in other known geographic races of this species.

Measurements.—The average and extreme measurements in millimeters of 12 adults from Hawkins and Hinchinbrook islands, Alaska, are as follows: Total length, 145.8 (135–158); tail, 33.1 (30–37); hind foot, 19.6 (19–20); condylobasal length, 25.0 (24.2–25.8); zygomatic breadth, 14.3 (14.0–14.6); length of nasals (11 averaged), 7.2 (6.7–7.7); breadth of braincase superior to external auditory meatus, 10.2 (9.9–10.8); crown length of maxillary tooth row, 4.9 (4.6–5.1).

Remarks.—The existence of this insular subspecies of *Clethrionomys dawsoni*, known only from two closely adjoining islands at the eastern entrance to Prince William Sound, is notable for several reasons. These islands are barely separated from one another by a narrow passage, according to Heller (1910). Hawkins Island, which is the easternmost of the two, however, is but several miles from the Alaskan mainland in the Cordova region where the race *orca* occurs. The latter subspecies, furthermore, is represented on several more distant islands in the western part of Prince William Sound.

In regard to certain characters, such as the possession of a relatively short hind foot and short nasals, *insularis* shows some resemblance to *orca*, although in other respects it is more nearly allied to *dawsoni*. This is indicated by the relatively pale color of both the dorsal and ventral body pelage and the fact that the top of the tail is reddish rather than blackish. The nearest known locality of occurrence for *dawsoni* is on the Kenai Peninsula. More information on the distribution of *Clethrionomys* in this region is essential before a clear understanding of the distribution of the species can be determined.

Specimens examined.—A total of 17 (coll. Univ. Calif. Mus. Vert. Zool.) from the following localities in Prince William Sound, Alaska: W. side Canoe Passage, Hawkins Island, 3; E. side Canoe Passage, Hawkins Island, 7; Northeast Bay, Hinchinbrook Island, 7.

Clethrionomys dawsoni orca (Merriam)

Evotomys orca Merriam (1900, p. 24), original description.

Type locality.—Orca, Prince William Sound, Alaska.

Range.—Known to occur on the Alaskan mainland bordering Prince William Sound and on several islands situated in the western part of the Sound.

Diagnosis.—Size medium; hind foot moderately short; hairs of dorsal parts of body relatively dark, exceeded in intensity of pigmentation in the species only by members of the race *watsoni;* top of tail blackish; tips of ventral guard hairs varying from whitish to moderately buffy; skull proportionately narrow across zygomata; nasals of medium length; braincase of medium breadth.

Measurements.—The average and extreme measurements in millimeters of 14 adults from Cordova, Alaska, are as follows: Total length, 140.8 (135–152); tail, 33.5 (30–39); hind foot, 19.4 (18.5–20); condylobasal length, 24.2 (23.1–25.7); zygomatic breadth, 13.6 (13.3–14.1); length of nasals, 7.3 (6.8–8.0); breadth of braincase superior to external auditory meatus, 10.2 (9.7–10.8); crown length of maxillary tooth row, 4.9 (4.5–5.2).

Remarks.—Clethrionomys d. orca, typically, is a very dark coastal subspecies, exceeded in intensity of pigmentation of the dorsal pelage only by *watsoni*. Its range on the mainland appears to extend completely around the shores of Prince William Sound, at least to Port Nell Juan on the eastern side of the Kenai Peninsula. A small series of specimens examined from Knight Island on the western side of the Sound are tentatively placed with this race. Although for the most part subadults, they average decidedly darker ventrally than specimens of *orca* from the mainland. In regard to this character, and also by the fact that in cranial breadth they average large, they show a definite tendency toward *watsoni*. This increase in cranial breadth was noted also in specimens from Hoodoo, La Touche and Chenega islands. Specimens from these three islands, however, showed only a slight tendency toward deeper pigmentation on the tips of the ventral guard hairs. It is possible that further collecting on Knight Island will reveal the existence of an additional insular form of *dawsoni*.

Specimens examined.—A total of 74 (coll. Univ. Calif. Mus. Vert. Zool.) from the following localities in the Prince William Sound region of southeastern Alaska: Valdez Narrows, 3; Ellamar, 1; head of Cordova Bay, 7; Cordova, 12; Port Nell Juan, 12; head of Port Nell Juan, 13; Chenega Island, 6; Knight Island, 2; Drier Bay, Knight Island, 6; Hoodoo Island, 9; La Touche, La Touche Island, 3.

Clethrionomys dawsoni watsoni, new subspecies

Type.—Adult female, skin and skull, no. 8968, California Academy of Sciences; from Cape Yakataga, Alaska; collected June 28, 1941, by Ben B. Watson; original no. 33.

Range.—Known only from the Cape Yakataga region of southeastern Alaska.

Diagnosis.—Size medium; color darkest of the known races of *dawsoni*, both dorsally and ventrally; top of tail blackish; tips of ventral guard hairs deep buffy; skull moderately narrow across zygomata; nasals of medium length; braincase relatively broad.

Measurements.—No measurements in the flesh were taken by the collector. The average and extreme cranial measurements in millimeters of 8 adults, including the type, from the region of Cape Yakataga, Alaska, are as follows: Condylobasal length, 24.1 (23.1–26.4); zygomatic breadth, 13.3 (12.8–14.2); length of nasals, 7.3 (6.8–8.3); breadth of braincase superior to external auditory meatus, 10.3 (10.1–10.7); crown length of maxillary tooth row, 4.8 (4.4–5.1).

Remarks.—Clethrionomys d. watsoni is named after Mr. Ben B. Watson who so kindly secured the series of red-backed mice here described as new. The existence of a distinct subspecific form of *Clethrionomys dawsoni* in the vicinity of Yakataga is not surprising in view of the relatively isolated position of this region biologically. Bounded on the north by Bering Glacier, on the south by Malaspina Glacier as well as several smaller glaciers that come down to the sea, to the east by the permanent ice cap covering the coastal mountains, including the Chugach and St. Elias ranges, and to the west by the Pacific Ocean, the area presents a biological island for those mammals unable to cross these formidable barriers.

Clethrionomys d. watsoni appears most closely allied to *C. d. orca*. This is indicated by the following characters: generally dark coloration, nasals of medium length, and reduced zygomatic breadth. It may readily be distinguished from the more northern race *orca*, however, by its even darker color as regards both dorsal and ventral body pelage and in

the possession of a relatively broad braincase. As commented upon in regard to *orca* (see Remarks under that race), specimens examined from Knight Island, in the western part of Prince William Sound, show a decided tendency toward *watsoni* although they are tentatively assigned to the former race pending the collecting of more material.

Specimens examined.—A total of 25 from the immediate vicinity of Cape Yakataga, Alaska.

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California Academy of Sciences, Golden Gate Park, San Francisco, California.

FOUR NEW ERMINES FROM THE PACIFIC NORTHWEST

By E. Raymond Hall

In a study of American weasels, four heretofore unrecognized subspecies from the Pacific Northwest require naming. Each of these subspecies belongs to the circumpolar species *Mustela erminea* Linnaeus of which the Old World ermine is probably the best known member. The vernacular name ermine is applied to each subspecies of *M. erminea* in the Old World, as it would seem useful to do also in America.

Detailed evidence in support of the view that the American and Old World ermines are conspecific will be presented in a later and more extensive paper treating of all the American weasels. In this later paper, characters for separating the several kinds of weasels will be given; for the present it will suffice to say that only two species of weasels are known from the geographic area shown on the accompanying distribution map. These are the long-tailed weasel, *Mustela frenata* (see Hall, Carnegie Inst. Washington, publ. no. 473, pp. 90–114, fig. 101, 1936) and the ermine *Mustela erminea*, treated in the present paper. In the geographic area shown in fig. 1, the adults of the two species, regardless of sex, may be distinguished as follows: In *M. erminea* the length of the tail-vertebrae is less, instead of more, than 47 per cent of the length of the head and body, and the postglenoid length of the skull is more, instead of less, than 47 per cent of the condylobasal length. Stated in another way: in the ermine the tail is shorter and that part of the skull behind the lower jaws is longer than in *Mustela frenata*, the long-tailed weasel. The condylobasal length of the skull in the kinds of weasels concerned is the greatest length, and the postglenoidal length as here employed is the distance along, or parallel to, the median longitudinal axis of the skull, from the posteriormost articular face of the glenoid fossa (socket for lower jaw) to the posteriormost part of the exoccipital condyle, which is the most caudal part of the skull.

Descriptions and names for the four new subspecies are provided below.

Mustela erminea invicta new subspecies

Type.—Male, subadult, skull and skin; no. 101122, Mus. Vert. Zool.; Benewah, Benewah County, Idaho; October 24, 1926; obtained by William T. Shaw.

Range.—Central Rocky Mountain region from Jasper Park south over Alberta, southeastern British Columbia, Washington (east of the Cascades), north and central Idaho and northwestern Montana.

Diagnosis.—Size: Ten males, adults and subadults, from central Idaho County, Idaho, show average and extreme measurements as follows: Total length, 291 (272–328); length of tail, 86 (75–100); length of hind foot, 39.9 (38–44). Five females, adults and subadults, from the same localities as the males, show average and extreme measurements as follows: Total length, 255 (245–270); length of tail, 71 (68–76); length of hind foot, 32.3 (32–33).

Color: Winter pelage all white except tip of tail which is black. Summer pelage with upper parts uniform in color and darker (16 *n*) than Raw Umber of Ridgway (Color Standards and Color Nomenclature, Washington, D. C., 1912) and about tones 3 to 4 of Choco-

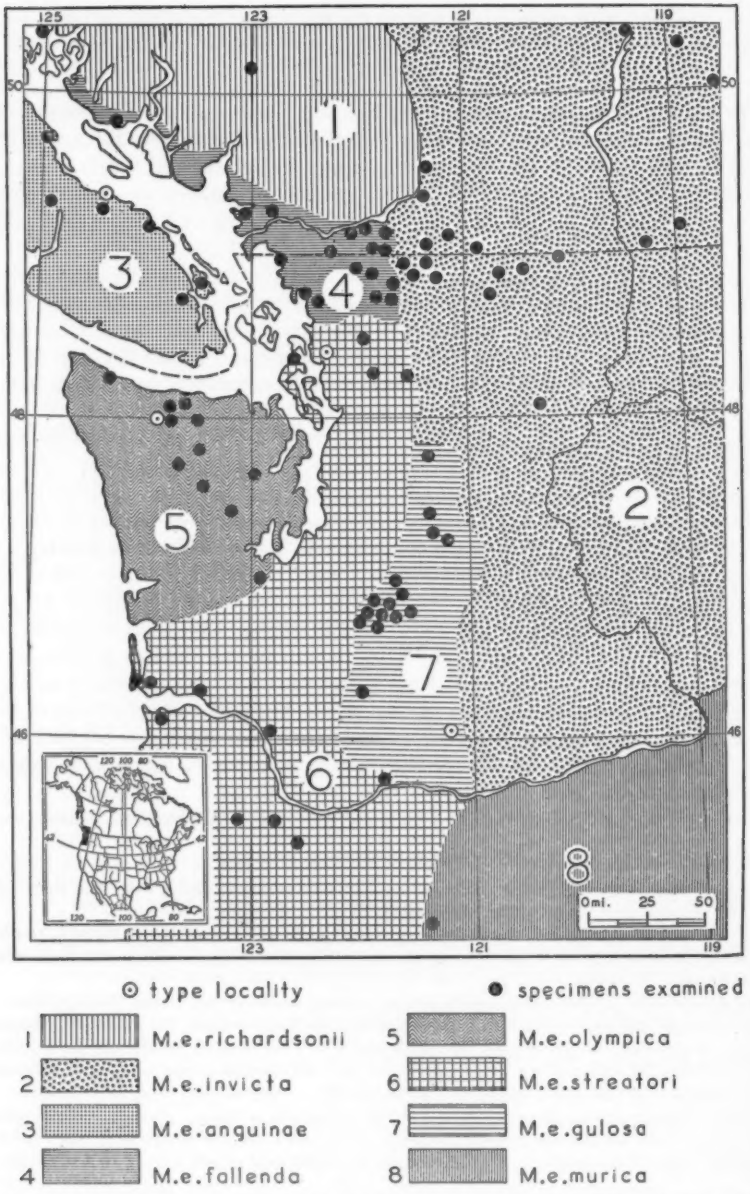

FIG. 1. Map showing the geographic distribution of subspecies of *Mustela erminea* in the Pacific Northwest.

late of plate 343 of Oberthür and Dauthenay (Répertoire de Couleurs, Rennes, Imp. Oberthür, Paris, Libraire horticole, 1905). Color of underparts in summer Marguerite Yellow (of Ridgway, *op. cit.*) or more whitish and extending narrowly over upper lips, distally on posterior sides of forelegs onto antipalmar faces of toes and sometimes over most of antipalmar surface of forefeet, on medial sides of hind legs to a point between knee and ankle but reappearing on antiplantar faces of toes and in some individuals is narrowly continuous onto toes. Least width of color of underparts averaging, in four females from Idaho and Montana, 38 (33–43) percent of greatest width of color of upper parts. Black tip of tail in same specimens 38 (31–42) mm., which is 57 (52–65) percent of length of tail-vertebrae.

Skull (5 adult males, 1 adult and 4 subadult females, all from Idaho County): Weight, including lower jaws, 1.5 (1.4–1.7) grams in males and 0.72 (0.7–0.9) grams in females; basilar length 37.0 (35.8–39.8) mm in males and 32.2 (31.6–32.8) mm in females; in each sex, length of upper tooth rows (taken on sagittal line of skull from anterior margin of incisors to posterior border of molars) less than length of tympanic bulla; breadth of rostrum in males less than a third and in females less than 30 percent of basilar length; in each sex interorbital breadth less than distance between glenoid fossa and posterior border of external auditory meatus; in each sex zygomatic breadth less than distance between last upper molar and jugular foramen.

Comparisons.—From *Mustela erminea fallenda*, selected differences of *invicta* are: External measurements larger; upper lips white, not brown; in relation to basilar length, skull of male with rostrum narrower and brain case shallower; skull of female shows the same differences but the degree of difference is about as great again; in female, breadth of rostrum less, instead of more. than 30 percent of basilar length; skull of female 18 percent heavier. From *Mustela erminea streatori*, selected differences of *invicta* are: External measurements larger (hind foot more, instead of less, than 35 mm in males and 29.5 in females); color of upper parts lighter; upper lips white rather than brown; skull and teeth averaging larger in every part measured except that the diameter of the inner lobe of the upper molar is less; skull 36 percent heavier in males and 12 percent heavier in females; in relation to the basilar length, skulls of males have longer tympanic bullae and a narrower rostrum and skulls of females are relatively narrower throughout and the tooth rows are shorter than in *streatori*. From *Mustela erminea gulosa*, selected differences of *invicta* are: External measurements larger (hind foot more, instead of less, than 35 mm in males and 29.5 in females); black tip of tail more, instead of less, than half of length of tail-vertebrae; in each sex, skull and teeth averaging larger in every part measured except that the inner lobe of the upper molar is the same in males and smaller in females; skull of male 50 percent heavier and skull of female 22 percent heavier; in each sex, in relation to the basilar length the tooth rows are shorter and the interorbital breadth is less. From *Mustela erminea murica*, *invicta* of corresponding sex differs in being larger in every measurement taken, external and cranial, excepting diameter of inner lobe of upper molar, which averages less in females and barely more in males; skull of male 83 percent heavier and that of female 20 percent heavier. In males, tympanic bullae longer in relation to basilar length, but shape of skull otherwise remarkably similar. From *Mustela erminea richardsonii* selected differences of *invicta* are: in male, skull lighter than 1.9 grams, mastoid breadth less than 19.9 mm, depth of skull at anterior margin of basioccipital less than 12.4 mm; in female, corresponding measurement of depth less than 10.1, and weight of skull less than one gram.

Remarks.—Until now animals of this subspecies ordinarily have been recorded in the literature as *Mustela cicognanii*, the kind of ermine inhabiting the northeastern United States. Their resemblance to *M. e. cicognanii* is marked. Actually *invicta* and *cicognanii* differ in several characters although in no one of these characters is the degree of difference sufficient to allow the use of it alone as a certain means of distinguishing between the two races. Incidentally the geographic ranges of the two races do not meet; in a sense, each is an independent southern derivative of the transcontinental race *richardsonii* and each is separated from the other by the Great Plains where weasels of the species *Mustela er-*

minea are not known to occur. In *invicta*, as compared with *cicognanii*, the light-colored underparts are wider in relation to the dark-colored upper parts, and the tail is longer by four percent in relation to the head and body. Given a population of each of the two subspecies in which the skull is of the same mass, the hind feet are longer in *invicta*, and there is more sexual dimorphism in size. Also, there is this average difference between the skulls of males: If the length of the upper tooth rows be taken as a standard (100 percent), the rostrum of *invicta*, as measured across the lacrimal processes, is broader (89 rather than 84 percent) but the width across the fourth upper premolars is less, 94 rather than 97 percent of the length of the tooth rows. This difference is not apparent to the eye and like each of the others mentioned is of an average sort. Therefore, and because over-all size is about the same in the two subspecies concerned, one or a few specimens from, say, central Idaho, can be distinguished from animals from western Pennsylvania only with difficulty, if at all. The close resemblance between skulls of *invicta* and *cicognanii* may be a function of their living at about the same latitudinal position in climates that agree in having well-marked seasons.

Intergradation with *richardsonii* is complete and gradual; in a sense *invicta* is but little more than a small *richardsonii*. Intergradation with *fallenda* is shown by several specimens. These two races differ in large degree in color, size and shape of the skull of females. Although the area where intergradation in color takes place is fairly wide, that in which intergradation in cranial characters of females occurs, appears, from the not entirely adequate material, to be much narrower. Intergradation occurs freely with *streatori*, but with *murica* it occurs, so far as known, only in the Bitter Root and nearby mountains of northwestern Montana. The Snake River Plains and low country along the Columbia River appear to be uninhabited by weasels of the species *erminea* and hence there is no opportunity for intergradation along the Snake and Columbia rivers.

Specimens examined.—Total number, 177, as follows: Arranged alphabetically by provinces and states then by localities from north to south in each province and by counties from north to south in each state. Unless otherwise indicated, specimens are in the United States National Museum. **Alberta:** Jasper House, 4^1; Shovel Pass, 2^1; Jasper Park, 10^1; head of Smoky River, 9; Henry House, 2 (1^1); Blindman River, 1^2; forks of Blindman River and Red Deer River, 2 (1^2, 1^4); "near Red Deer, Red Deer River," 1^1; Red Deer River, 2 (1^2, 1^3); Red Deer, 2^3; Rosebud, 2^1; Prairie, 3,000 ft., 1; Didsbury, Little Red Deer River, 1; Canadian Nat'l. Park, 1^3; Canmore, 1^1; Banff, 1^3; High River, 1^5; "Waterton Lake Park" in Alberta, 6^1. **British Columbia:** Grand Forks of Fraser River, 1; Canoe River, 1^1; Field, 1; Glacier, 1^6; E side Beaverfoot Range, 4,000–4,500 ft., 6 mi. SE Fraser Creek, 8^7; Wentworth Lake, 1^8; Revelstoke, 2 (1^1, 1^3); Spillimachen River, 2^3; Sicamous, 2; Albert River, 7,000 ft., 1^2; Lumby, Creighton Valley, 1^3; Okanagan, 4 (2^4, 1^9, 1^2); Kettle River Lake, Gold Range, 4,000 ft., 1; Crows Nest Station, 1^7; Yale District, 3; Fort Hope, 1; Chilliwack Lake, 1^1; Skagit, 2 (1^1, 1^3); Skagit Valley, 1^1; Skagit Summit, 1^1; Lightning Lakes, 2 mi. N International Boundary, 3; Osoyoos-Bridesville Summit, 2^1; Westbridge, 1^1; Rossland, 5^1; Creston, mouth Goat Creek, 3^1; Yahk, 4^1. **Idaho:** *Bonner Co.:* Coolin, 4. *Benewah County:* Benewah, 1^{10}. *Idaho County:* "Petes Kings, Locksa River," 1^{11}; 2 mi. SSE Selway Falls, 1,900 ft., 1^{12}; 4 mi. SW Selway Falls, 5,800 ft., 3^{12}; Newsome Cr., 12 mi. above jct. with S Fk. Clearwater River, 2^7; Iron Mtn., to 14 mi. W thereof, 24^7; Pilot Cr., ¾ to 2½ mi. above Newsome Cr., 4^7; Sawmill Cr., 1¼ mi. W Newsome, 1^7; between Selway River and S Fk. Clearwater R., 4^7. **Montana:** *Teton County* (of old arrangement of counties): Many Glacier, 4,900 ft., 1^7; Duck Lake, 6 mi. NE St. Marys Lake, 1; St. Marys, Glacier Park, 1^{13}; Lower St. Marys Lake, 1^3. *Flathead County:* Stanton Lake, 5. County in question: Bitter Root Mts., 1. *Ravalli County:* Tin Cup District, 1^7; Bass Creek, 6,800 ft., NW of Stevensville, 1; Capitan Peak, 7,000 ft., 1; Darby, 2^7; Girds Creek, 1^7; Charlos Heights, 2^7. **Washington:** *Whatcom County:* Twin Lakes, Winchester Mts., 3 (1^{14}); Chilliwack River, 2,600 ft., 2; Cooper Creek, near head, 4,500 ft., Hannegan Pass, 1; Cooper Cr., 4,300 ft., Hannegan Pass, 1^{14}; Beaver Creek (2,500 ft., and at McMillan Ranch, 1,700 ft.), 2; Barron, Bonite Mine, 5,000 ft., 1. *Okanogan County:* Tungsten Mine, 6,800 ft., Bauerman Ridge,

4; Hidden Lakes, 4,100 ft., 1; West Fork Pasayter River, 4,700 ft., 1. *Stevens County:* Orin, 1[15]. *Pend Oreille County:* Ione, 2[15]. *Chelan County:* Lake Chelan, 1[16].

[1] Canadian Nat. Mus.
[2] Amer. Mus. Nat. Hist.
[3] Field Mus. Nat. Hist.
[4] Mus. Comp. Zool.
[5] Royal Ont. Mus. Zool.
[6] Cornell Univ.
[7] Mus. Vert. Zool., Univ. Calif.
[8] Coll. Kenneth Racey.
[9] Mus. Zool., Univ. Wash.
[10] Coll. Wm. T. Shaw.
[11] Univ. Idaho.
[12] Calif. Acad. Sci.
[13] Mus. Zool., Univ. Mich.
[14] Chas. R. Conner Mus.
[15] Coll. Walter W. Dalquest.
[16] Coll. S. G. Jewett.

Mustela erminea fallenda new subspecies

Type.—Male, adult, skull and skin; no. 7096, Nat. Mus. Canada; Huntingdon, British Columbia; May 21, 1927; obtained by C. H. Young, original no. 317.

Range.—On mainland in immediate vicinity of coast from probably opposite Texada Island, British Columbia, south to Lake Whatcom, Washington, and to Mount Baker Range on International Boundary.

Diagnosis.—Size: Male: Seven adult topotypes show average and extreme measurements as follows: Total length, 278 (249–305); length of tail, 77 (69–81); length of hind foot, 36.5 (34–40). Female: Two adult topotypes, with actual measurements in parentheses, average as follows: Total length, 232 (228, 236); length of tail, 60 (57, 62); length of hind foot, 27 (27, 27).

Color: Winter pelage rarely white; brown winter pelage at some localities with slightly more smoky tinge than summer pelage; at most localities winter pelage of same color as summer pelage, which is uniform on the upper parts, ranging from Raw Umber to slightly darker (*16 n*) of Ridgway (*op. cit.*) and about tones 1 to 3 of plate 342 of Dark Chocolate of Oberthür and Dauthenay (*op. cit.*); underparts white, in summer rarely with a buffy suffusion on pectoral region; color of underparts extends from chin, and often lower lips, posteriorly to inguinal region, distally on posterior sides of forelegs onto antipalmar faces of toes (sometimes interrupted at and above wrist) and on medial sides of hind legs hardly to knee. Least width of color of underparts averaging, in 7 adult male topotypes, 18 (0–37) percent of greatest width of color of upper parts. Black tip of tail averaging, in same series, 45 (38–52) mm, which is 58 (53–65) percent of length of tail-vertebrae.

Skull (based on 7 adult males and 6 adult females): As described in *Mustela erminea invicta* except: Weight, 1.5 (1.3–1.7) grams in males and 0.85 (0.73–1.0) grams in females; basilar length, 35.7 (34.3–38.2) mm in males and 30.6 (29.4–31.7) mm in females; breadth of rostrum more than 30 percent of basilar length in females.

Comparisons.—Selected differences in comparison with *Mustela erminea richardsonii* are: Smaller; darker above and light-colored underparts much restricted by encroachment of dark-colored upper parts; upper lips brown rather than white; hind foot less than 41 mm in males and less than 29 in females; basilar length of skull less than 38.3 in males and 31.4 in females; skulls of males 40 percent and skulls of females 22 percent lighter than those of *richardsonii*; skulls of corresponding sex average smaller in every cranial and dental measurement taken with no overlap in many measurements; in relation to the basilar length, the rostrum (orbitonasal length) in each sex is longer, the interorbital region wider, and in females the rostrum is wider. From *Mustela erminea anguinae* of Vancouver Island, selected differences are: Females smaller; in both sexes, longer black tip on tail; greater sexual dimorphism especially in the skull, the male being three-fourths heavier than the female in this respect whereas in *anguinae* the male is only a third heavier. Males average larger in every cranial measurement taken; sagittal crest present rather than absent; tympanic bullae projecting from floor of brain case rather than flush with squamosal; in relation to basilar length, tympanic bullae larger, brain case shallower and narrower, skull narrower interorbitally and across zygomata. Females of *fallenda* are smaller; excepting the tympanic bullae, which average larger, every other part of the skull of *fallenda*

averages smaller; length of upper tooth rows less than length of tympanic bulla; anterior margins of tympanic bullae in many females protrude from floor of brain case, whereas margins of bullae are flush with squamosal in *anguinae*; in relation to skull as a whole, preorbital and interorbital regions larger in *fallenda*. From *Mustela erminea streatori*, selected differences are: In both sexes black tip of tail more than half of length of tail-vertebrae; in males hind foot more than 33.7 mm; tympanic bullae longer than, instead of about same length as, upper tooth rows; weight of skull more than $1\frac{1}{2}$ grams. In females, weight of skull more than 0.7 grams and length of lateral side of P^4 four mm or more. Comparison with *Mustela erminea invicta* has been made in the account of that subspecies.

Remarks.—Ermines from most of the localities here included within the geographic range of *fallenda* previously were assigned to *streatori*. Intergradation with *streatori* is complete, as it is also with *invicta* and *richardsonii;* that is to say, intergradation is complete with each of the subspecies whose ranges meet that of *fallenda*. In color and in size the difference is least between *streatori* and *fallenda*. As between *fallenda* and *invicta* the size is not greatly different and the intergradation in color is gradual. Between *fallenda* and *richardsonii* intergradation is somewhat different and to appreciate fully its nature we should remember that the color of *fallenda* in general resembles that of the saturate coastal races, *streatori*, *anguinae* and *olympica*. Despite the above-mentioned resemblances to the coastal races, *fallenda* resembles *richardsonii* in longer black tip of tail, in some cranial features and in greater degree of secondary sexual variation. Because the sexes differ more than in most subspecies of ermine whose ranges meet, some of the intergrades at first inspection appear to be widely different from either parent stock. For example, specimens from Alta Lake, British Columbia, may give this impression because the combination of large size and dark color suggests a kind of weasel different from either *fallenda* or *richardsonii*. In no instance, however, has there been found in these intergrades any character that does not occur in one or the other of the "parent" races.

Along the coast in the north part of the geographic range here assigned to *fallenda*, some specimens nearly typical of *richardsonii* have been taken so near the place where fairly typical *fallenda* was obtained that I have wondered if there is intergradation in the usual fashion in this area; more specimens will have to be obtained from the critical area to be sure.

The winter pelage at most localities is brown in all specimens. The only white pelage seen was in each of three specimens from Glacier, Whatcom County, Washington. A fourth specimen from there is in brown winter pelage. At any one locality there is much variation in the degree to which the dark color of the upper parts encroaches on the area that in the inland races is light-colored. An extreme degree of encroachment is shown by a specimen taken December 1, 1935, by R. A. Cummings, at Vancouver, British Columbia, in which the light color occurs only in three restricted areas—the chin, the throat and the lower breast; otherwise the coat is brown. There are other specimens, for instance from the type locality, that differ mainly in having an additional white spot in the inguinal region. The opposite extreme occurs in a specimen, also from the type locality, in which the least width of the light-colored underparts on the abdominal region is a third of the circumference of the body. The two extremes are connected by a dozen intermediate stages. Of 64 specimens in which the color of the lips was carefully examined, one, from Vancouver, has both the upper and lower lips brown; 9 have both the upper and lower lips white; and 54 have the upper lips brown and the lower lips white. The variation in color of the lips is far more than is found in other races.

Specimens examined.—Total number, 72, arranged by localities from north to south and unless otherwise indicated in the National Museum of Canada. **British Columbia:** Horseshoe Lake, Stillwater, 2; Vancouver, 1^1; Point Grey, 1^7; Port Moody, 5^3; Chilliwack, 8 (2^3, 4^3, 1^4); Sumas, 19 (18^3, 1^4); Thurstons Ranch, 2; Cultus Lake, 2; Mt. Baker Range, 5^3; Lihumption Park, 1; Huntingdon, 14; Tami Hy Creek, 1. **Washington:** *Whatcom Co.:*

Semiahmoo, 1[2]; New Whatcom, 1[5]; Lake Whatcom, 2[2]; 5 mi. W Glacier, 1[5]; Glacier (3 at 900 ft.), 4[2]; E side Easton Glacier, Mt. Baker, 1[6]; Morovitz Guard Station, 831 ft., 1[6].

[1] Mus. Vert. Zool., Univ. California.
[2] U. S. Nat. Mus.
[3] Mus. Comp. Zool.
[4] Field Mus. Nat. Hist.
[5] Leland Stanford, Jr. University.
[6] Coll. Wm. T. Shaw.
[7] Coll. Kenneth Racey.
[8] Coll. Walter W. Dalquest.

Mustela erminea olympica new subspecies

Type.—Male, adult, skull and skin; no. 90738, U. S. Nat. Mus., Biol. Surv. Coll.; near head of Soleduc River, 4,500 feet elevation, Olympic Mountains, Clallam County, Washington; April 28, 1897; obtained by Vernon Bailey, original no. 6213.

Range.—Olympic Peninsula south to Olympia, Washington.

Diagnosis.—Size: Twelve males of adult proportions show average and extreme measurements as follows: Total length, 243 (205–269); length of tail, 65 (60–74); length of hind foot, 31 (29–32). Corresponding measurements of six females are: 196 (188–208), 52 (45–60), 23.4 (22.7–24.0).

Color: As described in *Mustela erminea fallenda* except that least width of color of underparts averages, in 12 males, 5 (0–11) percent of greatest width of color of upper parts. Black tip of tail in same series, 26 (20–35) mm, which is 40 (31–58) percent of length of tail-vertebrae.

Skull: As described in *Mustela erminea invicta* except: Weight 1.0 (0.9–1.1) gram in males and 0.55 (0.52–0.58) gram in females; basilar length 31.8 (30.6–32.5) in males and 27.1 (26.7–27.5) in females; length of upper tooth rows in males more than or less than (about equal to) length of tympanic bulla; breadth of rostrum in females more than 30 percent of basilar length.

Comparisons.—From *Mustela erminea streatori* selected differences are: Size less, hind foot less than 33 in males and ordinarily not longer than 24 in females; skulls of corresponding sex average smaller in every measurement taken with no overlap in most measurements of females. Exception is to be made for the inner lobe of M^1 in males where the size is the same. By weight, skulls of males are 10 percent lighter and those of females 14 percent lighter. In relation to other parts of the skull the tympanic bullae are narrower in each sex and in females they are also shorter. From *Mustela erminea anguinae, olympica* differs in smaller external measurements in about the same way as described in the comparison with *streatori* although the difference between females is greater than in comparison with *streatori*. External measurements of 235, 65, 27.5 are smaller than in females of *anguinae* and larger than in *olympica*. In the skull, differences from *anguinae*, in males, are: Diameter of inner lobe of M^1 larger, but all other measurements of teeth and parts of skull averaging smaller; by weight, skull 17 percent lighter; upper tooth rows averaging about same length as, rather than always shorter than, tympanic bulla; in relation to basilar length, brain case shallower at anterior end of basioccipital and tooth rows longer. Differences between skulls of females include the following: Averaging 39 percent lighter; consistently smaller in every measurement taken; temporal ridges separated, rather than meeting at lambdoidal crest; length of upper tooth rows consistently shorter than tympanic bulla, rather than of about same length; in relation to basilar length, skull shallower, orbitonasal length less, mastoid and zygomatic breadths less; tympanic bullae longer.

Remarks.—The smaller size, especially of females, is the principal feature distinguishing this race from *streatori* with which intergradation is shown by specimens, assigned to *streatori*, from the southern end of Puget Sound. The differences between *olympica* and *anguinae* of Vancouver Island are of much greater degree than between *olympica* and *streatori*. On the basis of available data the female of *olympica* is smaller than that of any other race of the species and hence is the smallest adult weasel of the species *erminea* in either the Old World or America.

TABLE 1.—*Cranial measurements, in millimeters, of four subspecies of Mustela erminea*

CATALOGUE NO. OR NUMBER OF INDIVIDUALS AVERAGED	LOCALITY	BASILAR LENGTH OF HENSEL	LENGTH OF UPPER TOOTH ROW[1]	BREADTH OF ROSTRUM ACROSS LACHRIMALS	LEAST INTERORBITAL BREADTH	ORBITONASAL LENGTH[2]	MASTOID BREADTH	ZYGOMATIC BREADTH	LENGTH OF TYMPANIC BULLA	LENGTH OF M_1	LENGTH OF LATERAL SIDE OF P^4	BREADTH OF M^1	LENGTH OF M^1	DEPTH OF SKULL AT ANTERIOR MARGIN OF BASIOCCIPITAL	DEPTH OF SKULL AT POSTERIOR BORDER OF UPPER MOLARS
Mustela erminea invicta															
average		37.0	12.8	11.4	9.1	13.1	19.0	21.3	13.6	4.5	4.1	3.2	1.7	11.7	10.5
maximum ♂5 ad.	Idaho Co.	39.8	14.1	13.0	10.0	14.2	19.7	22.6	14.2	4.9	4.3	3.5	1.9	12.3	11.3
minimum		35.8	12.2	10.6	8.6	12.0	18.2	20.5	13.3	4.2	4.0	3.1	1.4	10.9	9.7
average		32.2	10.6	9.0	7.1	11.1	16.3	17.2	12.0	3.9	3.7	2.8	1.4	9.5	8.3
maximum ♀ 1 ad. and 4 sad.	Idaho Co.	32.8	11.2	9.2	7.2	12.2	17.0	17.8	12.7	4.3	3.9	2.9	1.5	10.0	8.7
minimum		31.6	10.8	8.5	7.0	10.5	15.6	16.5	10.9	3.5	3.6	2.7	1.3	9.0	8.0
Mustela erminea fallenda															
average		35.7	12.6	11.1	9.2	12.5	18.3	20.8	13.1	4.6	4.2	3.4	1.9	11.7	10.5
maximum ♂7 ad.	topotypes	38.2	13.1	11.6	9.9	13.0	19.6	22.8	14.1	4.9	4.5	3.5	2.1	12.4	11.0
minimum		34.3	12.0	10.5	8.3	12.0	17.0	19.4	12.2	4.5	3.9	3.2	1.7	11.0	10.0
average		30.6	10.2	9.1	7.4	10.6	15.5	17.2	11.1	3.8	3.5	2.7	1.4	10.1	8.6
maximum ♀5 ad.	(2 topotypes and 3 Sumas)	31.7	10.3	9.6	8.0	11.0	16.0	18.5	11.5	4.1	3.7	2.9	1.5	11.0	9.0
minimum		29.4	10.1	8.6	7.1	10.1	14.7	15.4	10.5	3.7	3.4	2.6	1.2	9.3	8.2

Mustela erminea olympica

average			31.8	11.3	9.8	7.9	11.5	16.0	18.1	11.3	4.2	3.7	2.9	1.8	10.1	9.0
maximum	♂ 5 ad.	Olympic Peninsula	32.5	11.7	10.2	8.2	12.3	16.9	18.8	11.6	4.3	3.8	3.1	2.1	10.3	9.3
minimum			30.6	10.9	9.2	7.4	10.0	15.0	17.2	10.7	4.0	3.5	2.7	1.7	9.9	8.6
C.R.C.M.[3]	96 ♀ ad.	Elwha Riv.	27.5	9.4	8.3	6.9	9.3	13.2	15.3	10.2	3.4	3.0	2.5	1.3	8.5	7.2
C.R.C.M.	1164 ♀ ad.	12 mi. S Port Angeles	26.7	9.0	8.1	6.7	9.0	13.1	14.4	9.7	3.4	3.1	2.3	1.3	9.0	7.3
U.S.N.M.[4]	242133 ♀ ad.	Hayes Creek	27.2	9.2	8.4	7.2	9.2	13.7	15.4	9.5	3.3	3.0	2.1	1.2	8.3	7.2

Mustela erminea gulosa

U.S.N.M.	82177 ♂ ad.	Trout Lake	32.0	11.3	10.1	8.5	11.2	16.3	18.3	11.3	4.2	3.8	2.9	1.6	10.5	9.4
U.S.N.M.	64768 ♂ ad.	Trout Lake	33.3	12.0	9.9	8.3	12.2	16.9	18.5	11.8	4.2	3.7	2.8	1.8	10.6	9.4
U.S.N.M.	81919 ♀ ad.	Trout Lake	28.1	9.7	8.8	7.0	10.0	13.8	15.4	10.1	3.6	3.2	2.3	1.4	8.1	7.3
U.S.N.M.	87039 ♀ ad.	Trout Lake	28.4	9.8	8.7	7.1	10.8*	14.5	15.6	10.0	3.5	3.2	2.5	1.4	8.6	7.5
U.S.N.M.	77370 ♀ ad.	Trout Lake	27.8	9.6	8.6	6.6	9.3*	13.6	15.2	9.7	3.8	3.4	2.7	1.5	8.1	7.2

[1] Along median longitudinal axis of skull from anterior faces of incisors to a line connecting posterior margins of molars.

[2] Measured diagonally from posteriormost margin of anterior nares to posterior side of postorbital process near its tip.

[3] Charles R. Conner Museum, Washington State College.

[4] United States National Museum.

[5] Approximate.

Every specimen seen in the winter coat was brown, not white. The color of the upper parts is uniform and the color pattern varies less than in geographically adjoining races. The white color of the underparts is restricted to a thin line on the abdominal region, but widens out posteriorly in the inguinal region and anteriorly over the pectoral region, throat, chin and lower lips. The upper lips are brown. The brown of the upper parts extends around in front of each foreleg, the brown area of one side not quite meeting that of the opposite side on the lower throat.

Specimens examined.—Total number, 20, arranged by localities from north to south. Unless otherwise indicated specimens are in the United States National Museum. **Washington:** *Clallam Co.:* Clallam Bay, 2([1], [2]); Elwah, 2[2]; Johnsons Ranch, 1[4]; Happy Lake, 1[4]; Boulder Lake, 2[4]; near head of Soleduc River, 4,500 ft., 1; 12 mi. S Port Angeles, 1[3]. *Jefferson Co.:* Hayes Cr., 2,000 ft., Elwah River, 2; head N Fork Quinault River, 4,000 ft., 1; Duckabush, 3; N Fork Skokomish River, 1. *Mason Co.:* Lake Cushman, 2[5]; 4 mi. S Olympia, 1.

[1] Mus. Vert. Zool., Univ. Calif.
[2] Mus. Zool., Univ. Wash.
[3] Charles R. Conner Mus.
[4] Field Mus. Nat. Hist.
[5] Mus. Zool., Univ. Michigan.

Mustela erminea gulosa new subspecies

Type.—Male, subadult, skull and skin; no. 81998, U. S. Nat. Mus., Biol. Surv. Coll., Trout Lake, Klickitat County, Washington; February 3, 1897; obtained by P. Schmide, original no. 147.

Diagnosis.—Size: Five males of adult proportions from Mount Rainier show average and extreme measurements as follows: Total length, 253 (233–282); length of tail, 76 (56–83); length of hind foot, 30.2 (26–33). Four adult females, two from Mount Rainier and two from Trout Lake measure as follows: Total length, 202, 203, 216, 210; length of tail, 54, 52, 57, 51; length of hind foot, 24, 24, 25, 24. The average measurements for these four females are: 208, 54, 24.3.

Color: As described in *Mustela erminea invicta* except that winter pelage of some individuals brown (with more smoky tinge than summer coat) in winter; upper parts ranging from tone 2 through tones 3 and 4 of Dark Chocolate (plate 342) into tone 4 of Chocolate (plate 343) of Oberthür and Dauthenay (*op. cit.*); underparts (always white in winter) in summer Sulphur Yellow or whitish; least width of color of underparts averaging, in 5 males from Mount Rainier, 31 (18–45) percent of greatest width of color of upper parts. Black tip of tail, in same series, averaging 34 (29–40) mm, which is 45 (41–50) percent of length of tail-vertebrae.

Skull (based on 2 adult and 13 subadult males, and 5 adult females, all topotypes except 1 female from Mount Rainier): As described in *Mustela erminea invicta* except: Weight, 1.0 (0.95–1.16) gram in males and 0.59 (0.53–0.65) gram in females; basilar length, 32.3 (30.9–33.4) mm in males and 28.1 (27.8–28.4) mm in females; length of tooth rows in males about equal to (more than or less than) length of tympanic bulla; breadth of rostrum in females ordinarily more than 30 percent of basilar length.

Comparisons.—Differences from the larger *Mustela erminea invicta* of the same general color pattern have been mentioned in the account of that race. In comparison with *Mustela erminea streatori*, *gulosa*, both sexes, has upper lips white not brown; light color of underparts extend down hind leg below knee, rather than terminate at knee or some point above it; in corresponding sex, teeth about same size; every cranial measurement averages larger; skull and lower jaws lighter by 9 percent in males and 8 percent in females. *M. e. gulosa* is further distinguished by the shallower skull, which at the posterior border of the upper molars measures less than 7.7 mm in depth in females and ordinarily less than 9.6 mm in males. In relation to the basilar length the tympanic bullae of females of *gulosa* are shorter. In that sex the skull is shallower and, on the average, the zygomata are less expanded. In comparison with *Mustela erminea murica*, *gulosa* is darker-colored on the upperparts and the least width of the light-colored underparts averages only about one-

third, instead of about two-thirds, of the greatest width of the dark-colored upperparts. Females of the two subspecies are of about the same size, but males of *gulosa* are larger, the basilar length amounting to more than 30.8 mm, the skull and lower jaws weighing one gram or more and the length of the tail-vertebrae averaging more than 65 mm. In males of *gulosa* the skull averages larger in every measurement taken, is 23 percent heavier and in relation to other dimensions the brain case is shallower at the anterior end of the basioccipital. In females, in relation to the basilar length, the brain case is shallower and the breadth across the mastoids and across the zygomata is less. From *Mustela erminea fallenda*, *gulosa* differs more than from *streatori* or *murica* and can be distinguished by the following selected points: Anterior margin of tympanic bulla flush with squamosal rather than projecting below floor of brain case (difference slight in females); in males hind foot less than 33.5, weight of skull less than 1¼ grams, basilar length less than 33.9; in females, total length less than 222, hind foot less than 26, weight of skull less than 0.7 grams, and basilar length less than 29.

Remarks.—Of the 21 specimens in winter pelage, 17 are white and four are brown. The brown winter coat is distinctly paler, with more of a smoky tinge, than the brown summer pelage. The light-colored underparts are narrower than in the subspecies immediately to the east but are wider than in the coastal forms to the west. The dark color of the upperparts extends onto the chest in front of the forelegs, as in the coastal forms, in only one of the 13 specimens in summer pelage, and it on one side only. The black tip of the tail is short as in the coastal forms.

M. e. gulosa is not a strongly marked race and in most of the characters used for differentiating it from other races it resembles either *streatori* to the west or *murica* to the southeast. Nevertheless there is a geographic area, the southern Cascades of Washington, throughout which individual characters are combined in essentially the same way; furthermore, there are a few features, for instance smaller skull of the female, in which *gulosa* does differ from either of its close relatives. In view of these circumstances and because the animals in the southern Cascades can not well be included in the subspecies *streatori* or *murica*, *gulosa* is recognized as distinct. The races *gulosa* and *olympica* are what might be termed weakly differentiated subspecies in contrast to the strongly differentiated subspecies *streatori* and *murica*.

Specimens examined.—Total number, 38, arranged by counties from north to south. Unless otherwise indicated, specimens are in the U. S. National Museum. **Washington:** *King Co.:* 2 mi. E Skykomish, 2[1]. *Kittitas Co.:* Keechelus Lake, 3 (1[2]); Martin, 1[2]; Easton, 3. *Pierce Co.:* James Lake, 4,370 ft., Mt. Rainier, 1; Glacier Basin, 5,935 ft., Mt. Rainier, 1; Meslers Ranch, 2,000 ft., 1 mi. W Rainier Park, 1. *Lewis Co.:* Mt. Rainier Nat'l. Park (1 each from: Paradise Park, 5,400 ft.; Reflection Lakes, 4,900 ft.; Ohanapecosh [Hot] Springs, 2,000 ft.; Tahoma Creek[3]; Bear Prairie), 5; also in Mt. Rainier Nat'l. Park, Longmire, 3 (1[3], 1[4]). *Skamania Co.:* Mt. St. Helens, 6,000 ft., 1. *Klickitat Co.:* Trout Lake, 18.

[1] Coll. Walter W. Dalquest.
[2] Acad. Nat. Sci. Phila.
[3] Mt. Rainier Nat'l. Park Coll.
[4] Mus. Zool., Univ. Wash.

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University of Kansas, Lawrence, Kansas.

GENERAL NOTES

BODY TEMPERATURES OF SMALL MAMMALS

Wislocki (1933) compiled the scattered and fragmentary data on body temperatures of mammals and found very few records available on rodents and none on shrews. Przibam (1917) and Bierens de Haan (1922) believed they demonstrated in a European mouse and rat that the female possessed a temperature about 0.5°C. higher than the male and Przibam found that a change of 5°C. in air temperature was accompanied by a change of 0.75°C. in body temperature.

During the summer of 1942 and 1943 the writer had an opportunity for field studies at the Edmund Niles Huyck Preserve at Rensselaerville, 30 miles south of Albany, New York. An indicator potentiometer calibrated directly into degrees temperature and using copper-constantan thermocouples was available. Small mammals were caught alive in Sherman traps, brought into the laboratory, kept in cages, and their temperatures recorded at intervals. The accuracy of the apparatus was such that while individual readings might be in error by two or three tenths of a degree, these errors tended to cancel out in the averages. The warm junction of the thermocouple wire was silk insulated, coated with collodion except at the junction of the two metals, twisted together, and then recoated with collodion to form a flexible, water-proof, thin thermometer. With mice it was possible to thrust the sensitive tip well down the throat, often clear to the stomach; with shrews and squirrels it was thrust well up into the rectum. In all cases it was inserted far enough to get true body temperatures. The animal was held in the left hand as temperatures were read, while the right hand was free to manipulate the thermocouple and potentiometer and do the recording. While kept in captivity the animals were supplied with water, corn, or meat. The time of last feeding and the amount of activity previous to taking of temperatures varied considerably but was sometimes known.

Exercise had considerable effect on the body temperature. For instance, an adult male white-footed mouse that had been quiet in its cage, caught without struggling, but then began to wiggle around in the hand, had the following rise in body temperature in less than six minutes: 35.1, 35.9, 36.0, 37.3, 36.8, 37.0, 37.0°C. Another adult male mouse that had been active but was quiet while in the hand had a drop of temperature during five minutes: 39.5, 38.5, 37.5, 36.2, 35.9, 35.4, 35.3°C. A short-tailed shrew (*Blarina brevicauda kirtlandi* Bole and Moulthrop) studied in northern Ohio had a drop in body temperature in 10 minutes, as it quieted down, from 37.4° to 35.2°C.

In the accompanying table, the average temperature is for all records obtained and may represent the body temperature of animals undergoing varied activities in their natural environment, the maximum temperature occurs under excitement and intense activity, while the lowest normal temperature is when the mouse is at rest. This latter temperature should approach the temperature of standard or basal metabolism, but this could not be obtained on all individuals. In the most probable cases the standard or basal temperature appeared to lie between 35° and 36°C.

The air temperature was always taken at the time body temperatures were recorded, but no correlation between the two was evident. Exposure of animals induced by several hours in the traps often produced a lowering of body temperature from which recovery was not always possible. Four *Peromyscus* did not survive body temperatures down to 32.7, 32.5, 30.5, and 25.5°C. respectively, but strangely one mouse fully recovered after its body temperature had fallen to 23.4°C. A single *Napeozapus insignis* had a subnormal temperature of 31.1°C. when taken from the trap at 5:50 p.m. The next morning it was down to 22.2°C. and it died shortly after. The temperature of *Blarina* invariably dropped when held in captivity and the lowest record obtained was 31.4°C. On the other hand, the *Sorex* was very excited and breathing hard as its temperature was obtained just before it died, apparently from some effect accompanying this excitement.

Insufficient data are available to demonstrate possible differences between sexes and ages. Likewise conditions were not favorable for demonstrating any possible daily rhythm, although in nocturnal *Peromyscus*, temperatures averaged about 1°C. higher in the morning after a night of presumed activity than in the afternoon or evening after a day of rest.

TABLE 1.—*Temperatures of small mammals*

SPECIES	AGE	SEX	DAYS CAPTIVE	NUMBER OF RECORDS	AVERAGE	MAXIMUM	LOWEST NORMAL
					°C.	°C.	°C.
Peromyscus maniculatus gracilis—White-footed mouse	ad.	M.	5	10	37.9	40.3	35.3
	ad.	M.	6	7	36.9	38.4	35.1
	ad.	M.	2	4	38.0	40.3	35.0
	ad.	M.	1	1	—	40.7	—
	ad.	F.	1	1	—	41.2	—
	juv.	M.	44	16	38.6	39.5	37.2
	juv.	M.	34	13	38.3	42.3	35.0
	juv.	M.	4	8	39.5	40.4	38.8
	juv.	M.	2	4	37.6	40.4	35.5
	juv.	—	5	3	37.3	38.1	37.0
Tamias striatus lysteri—Chipmunk	—	M.	1	1	—	40.0	—
	—	F.	3	6	38.6	40.1	36.5
Blarina brevicauda talpoides—Short-tailed shrew	—	M.	1	1	—	37.7	—
	—	—	1	1	—	—	34.5
	—	—	1	3	35.7	36.5	34.9
Sorex f. fumeus—Smoky shrew	—	F.	1	1	—	37.8	—

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S. CHARLES KENDEIGH, *University of Illinois, Champaign, Illinois.*

SOME WINTER FOODS OF THE COTTONTAIL IN SOUTHERN MICHIGAN

During late November and early December, 1942, I noted that numerous pods of honey locust (*Gleditsia triacanthos*) were being excavated from under one to two inches of snow and fed upon by cottontails (*Sylvilagus floridanus mearnsii*). The pods had fallen from a tree growing on the steep north hillside beside the Laboratory of Vertebrate Biology on the campus of the University of Michigan in Ann Arbor. An abundance of cottontail tracks in the snow around the freshly excavated pods left no doubt of the species of animal involved. Some of the pods had been chewed only along one edge and the seeds extracted and eaten. Other pods, however, were almost completely demolished and it seems certain

that a considerable amount of the pod material had been eaten in addition to the seeds. A few pods were later excavated by the rabbits from under snow seven inches deep.

When in the following January the snow had reached a depth of 15 inches, by Weather Bureau report, the cottontails were still feeding somewhat on the honey locust pods, but the signs all indicated that the pods secured were those that had previously been worked over when the snow was not so deep, and that the animals were not digging through the 15 inches of snow to secure additional pods.

During this January period of deep snow and cold weather, which reached to 11 degrees below zero Fahrenheit, the rabbits mostly turned their attention to some small pines and spruces. These conifers had been artificially planted and their species were not determined. It is possible that some of them at least were of European origin. The pines (*Pinus*) were attacked first and from the evidence of the trimmings left in the snow both the needles and the smaller twigs were consumed. Some needles evidently were eaten directly from the tree, but frequently a small branch, not over a half inch in diameter, would be cut off and the needles and many of the smaller twigs eaten down to between an eighth and a half inch of the stem. The remnants of the branch would be left lying on the snow. Ultimately all the smaller pine branches within reach of the rabbits from the top of the snow were pruned away. Then the rabbits began to attack some small spruces (*Picea*). Of these also both the needles and the smaller twigs were eaten. Pine, however, was obviously prefered over spruce as browse. There was no suggestion of any girdling of the trunks of the trees, which had diameters of from two to three inches. No evidence of feeding on other trees or shrubs was noted. However, no willows or other shrubs of types most frequently used by rabbits for winter food were growing in the vicinity.

As soon as the snow melted off the ground in late winter the rabbits must have found more palatable food elsewhere for there was no further evidence of their feeding on either the honey locust pods or on the needles of the conifers.—Lee R. Dice, *University of Michigan, Ann Arbor, Michigan.*

BACHMAN'S SHREW FROM POLK COUNTY, FLORIDA

A single specimen of Bachman's shrew (*Sorex longirostris*) was taken January 9, 1944, near Davenport, Florida, in a dense swamp that extended for about a hundred yards on either side of a shallow, slow-running creek. The chief floral elements of the community were cypress, bay, gum, elderberry, wild grape, bramble, ferns and mosses. The area was only a few inches above the level of the creek and moist, even in the dry winter season; it was probably flooded in summer. The trap in which the shrew was caught was baited with bird seed and walnut, but the animal was headed away from the bait and may have stumbled into the trap by accident.

Other mammals secured in approximately 400 trap nights in the swamp were: cotton mouse (*Peromyscus gossypinus*), 12; golden mouse (*Peromyscus nuttallii*), 6; cotton rat (*Sigmodon hispidus*), 2; rice rat (*Oryzomys palustris*), 2; and wood rat (*Neotoma floridana*), 1. Oven birds and towhees were common and a flock of jays were seen mobbing something I could not locate.

The shrew, a male, had scrotal testes, about 5 mm long, but they did not appear fully active. Its measurements (in millimeters) were: total length, 88; tail, 31; hind foot, c.u., 11.5 (s.u., 10); ear, from notch, 8. It weighed 4.5 grams.

The known range of the Bachman shrew is extended about 95 miles southward from the previous record for Welaka, Putnam County, Florida (Moore, Jour. Mamm., vol. 24, pp. 404–405, 1943).—John Eric Hill, *The American Museum of Natural History, New York, N. Y.*

WAR STATUS OF PREDATORS IN NORWAY

(The following is translated from Ukens nytt fra Norge, vol. 1, no. 298, October 21, 1943, p. 8.)

The Germans no longer depend on NS (National Samling, Nazi party in Norway) members whose continued usefulness and glowing enthusiasm for Hitler and everything German

has been diminishing of late. As one good example of the German's dying trust in the Norwegian Nazi, is the fact that in the Snaasa district, where the elk season has just opened, only 8 NS members were given hunting permits as compared to 34 last year. This year it is mostly the Germans who are hunting in the Snaasa forests, with no regard whatsoever for the game population or the Conservation laws.

Because of the fact that all guns and hunting equipment have been requisitioned by the Germans, the number of predatory animals has steadily increased, and there are now more bears, foxes, wolves, and wolverines in Norway than there have been in many years. Last year the wolves came as far south as Dovre and the mountain districts of Gudbrandsdal and Osterdal. A total of 52 sheep were lost from two farms in one night: 35 from one and 17 from the other. Many of the farmers in these districts did not send the sheep to the mountains at all this summer. Landowners and officers of the Farmer's Associations have repeatedly requested hunting permits, guns and ammunition, but to no avail—so don't come to us and say that the Germans invaded Norway "to protect us."—ALDO LEOPOLD AND HANS PETER THOMSEN, *University of Wisconsin, Madison, Wisconsin.*

ANOTHER RECORD OF THE BADGER AS A HIGHWAY CASUALTY

While many mammals have been reported as highway casualties, the writer knows of only one published account of the badger, *Taxidea taxus* (Schreber), having been killed by automobile traffic. This one was reported by Stoner (Nature Notes vol. 9, p. 50, 1943); he found the casualty in eastern Colorado on August 31, 1941. The writer found another example of this mammal as a highway casualty on Route 33, about 40 miles due north of Helena, Montana, in the early morning of August 9, 1941. The specimen was fresh, and was apparently killed during the preceding night. The species is known to be common, but because of its fossorial habits and its shy, cautious nature it is seldom seen. If the badger had greater range above ground it would probably be killed on the highway more often inasmuch as it is slow and clumsy in its movements.—RALPH W. DEXTER, *Kent State University, Kent, Ohio.*

ADDITIONAL RECORDS OF BADGERS KILLED ON HIGHWAYS

Dexter's account above prompts me to place on record two additional instances of badgers (*Taxidea taxus berlandieri*) being killed on highways. Early on the morning of August 31, 1938, an adult female was found dead at the side of the highway five miles east of Fort Stockton, Pecos County, Texas. The animal was in good condition and was preserved as no. 704 in the Texas Cooperative Wildlife Collection. The stomach was empty.

The second record is that of an adult male found on the afternoon of July 16, 1940, on the Pan American highway about 30 miles south of Nuevo Laredo, in Nuevo Leon, Mexico. This animal had been killed in the middle of the highway and had been run over by several automobiles. The advanced stage of decomposition indicated that it had been dead at least two days.—W. B. DAVIS, *Department of Fish and Game, College Station, Texas.*

CHASE LITTLEJOHN, 1854–1943: OBSERVATIONS BY LITTLEJOHN ON HUNTING SEA OTTERS

Mr. Chase Littlejohn died in the town of San Mateo, California, May 25, 1943. His sister, Mrs. Flors Easterday of Tunitas Glen, San Gregoria, California, records [*in Litt.*] his birth as in Redwood City, California, April 3, 1854, the son of William and Emma Matilda (Doyle) Littlejohn, and that Chase Littlejohn was married successively to Nellie Koen, Jane Koen, and Anna Schneider but had no children. Mr. Littlejohn claimed to have been the first white boy born in Redwood City.

He collected birds and mammals as study specimens over a long period. These are distributed in many collections; Leland Stanford Junior University has several hundred of the mammals. Littlejohn was a keen observer and drew on his observations to collect intelligently. Therefore the specimens that he obtained contributed much to a better knowledge of natural history, particularly of California and Alaska.

One of his infrequent visits to the Museum of Vertebrate Zoology, at Berkeley, was when

the late ProfessorJoseph Grinnell and Dr. Jean M. Linsdale and Mr. Joseph S. Dixon were preparing an account of the sea otter for "The Fur-bearing Mammals of California," Univ. Calif. Press, Berkeley, 1937. The conversation had to do with sea otters and Chase Littlejohn assented to Professor Grinnell's suggestion that Miss Ruth H. Woodman take down in shorthand some of Littlejohn's comments. Extracts from these comments, made on August 10, 1933, follow:

"As late as 1885 I was located on Sanak Island [Alaska] . . . [The natives on dark nights hunted by] feeling all over the rocks until they located the otter . . . they would just feel along and find his head and hit him a light tap for fear of waking the other ones up and then they would go along and hit another. . . . There would be two or three [natives] in each one (bidarka) so as to cover the rock in a short time. After they had gone all around, then they would club them [otter] to death and drag them on the rock. . . .

"They say years ago that the only way they got most of the otter was to club them.

"Over on the Kuril Islands there was a flat rock probably two acres in extent. The sea washed over it at every heavy tide. This island was not hunted much because there was no anchorage. . . . One year we went there and that rock looked like a seal rookery with otter. There was something between 70 and 80 on that rock. We just kind of got on three sides of the rock with our boats and kept them running back and forth. Very difficult to hit them on the rocks. They go fast; they are much quicker than a seal on the rocks. There was kelp on the rock. They would scoot 20 or 30 feet. . . . Those fellows would get overboard in spite of all, but we killed quite a number.

"Yes, shooting on the water. We never clubbed any ourselves, but the natives clubbed them on the rocks. . . .

"The young are either born on the rocks or at sea. I have seen them off Sanak Island. There is a [place] . . . about 50 fathoms deep where they go to the depth of the water to feed. I have seen them there—the old mother with the little pups, as we called them, a day old. They have wool on . . . but can't swim. If the mother drops them they would sink. The mother carries them in her arms. They cry like a baby. The otter swims on the back except when it dives and then it turns over. . . . I believe that naturally they went ashore to have their young, but since they have been hunted and harassed they are born out at sea. They do not have time to go out to the land and back during the dark of the night, because the night is so short they couldn't possibly go out and back again. We often hunted them until nine o'clock at night and then went out again at two o'clock in the morning.

". . . There are ways of signalling with a paddle. If a man sees an otter, the man steering the boat held up his paddle for a signal that the otter had been sighted. The other boats swing into position so as to form a triangle."

Speaking of his brother thinking that he sighted otter one day, he said: "He pulled toward it and looked with his glasses. We had not gone more than a hundred yards until up went his paddle again. He thought he saw an otter lying asleep in the bunch of kelp. . . . finally he shot and the whole bunch of 'kelp' disappeared. We closed in on them. . . . they finally got away out of range of us. We hunted around a while longer but we went back with 25, . . . all we got out of that bunch. There was twice that number left—fully 75 in that 'school.' Next morning we went out again to hunt, but only got two or three when the wind came up and the water became rough. . . .

"Santa Barbara . . . hunted. They were the first real white men to hunt. I started out once and went up as far as the Big Sur River. We couldn't get ashore. . . . He [Nidever] had been down . . . and said we could land at the mouth of the river, but he must have struck it when it just happened to be smooth. There was a vaquero came down to us. . . . He said we might stay there for 6 months and not get a chance to land. . . . but my brother hunted down there. He hunted two or three years—between 1875 and 1880. George W. Littlejohn . . . away down into Mexico. . . . different places . . . out on Santa Barbara Island and San Clemente. Also in San Mateo County—Año Nuevo. I think he got one at Pigeon Point. . . .

"The fur is just as pretty but shorter (southern *vs.* northern Otter).

"The fur is the same the year around. They are worth just as much. There is a gradual shedding of the fur little by little. They are not like land animals. . . . only a difference of 2 to 4° [F.] in the water in summer and winter, but of course in the winter the air is much colder. If they are not disturbed they spend their lives just in one locality—just within a few miles.

". . . I saw him [Nidever] eight years ago—seven or eight. The otter and seal hunters had a case against the Government. . . . a couple of attorneys in San Francisco . . . took it up for us with the Government to try to get something for the old hunters. . . . [the attorneys] were to get 40 percent. They had to make several trips back to Washington. I got $1100. . . . they picked out what the average 'catch' would be and they paid us accordingly. I had only a couple of years that I had anything coming to me. Different . . . in different years.

"Although I had never met him [Nidever], my brother knew him and we asked Mr. North if he had communicated with him. 'We will have to get in touch with him!' . . . so several of the men went down to Santa Barbara. The old man was blind and was living with his daughter. They thought it was some trick and they weren't a bit enthusiastic. Then I went down; I did not go on purpose, but that was one object. . . . I had an old schoolmate living there for years and so I hunted him up. While I was talking to him I said, 'Do you happen to know a man here by the name of George Nidever?' 'Do I know him—he is my next door neighbor.' . . . I went there and met him and his daughter. I happened to speak to them about this money. 'You go ahead and do everything the attorney tells you to do and you will get some money out of it.' And if it hadn't been for me they would not have put in a claim. He was an old man and blind . . ."

Mr. Hart H. North of 2414 Prospect Avenue, Berkeley, California, in oral interview on November 16, 1943, told me that the Nidever to whom Littlejohn referred was George Nidever, a son of George Nidever who also hunted sea otters. An account of the latter is "The Life and Adventures of George Nidever [1802–1883]. . ." edited by William Henry Ellison, University of California Press, Berkeley, 1937. Mr. North told me also that it was himself to whom Littlejohn alluded in the above account, and that Mr. North and his partner in law recovered in excess of $2,000,000 to compensate for losses sustained by Littlejohn and other hunters and companies when the United States government in 1886 to 1893 enforced an act prohibiting sealing in Alaska or the waters thereof. As applied to waters more than three miles off shore, the act was subsequently judged illegal. Because the act had been enforced widely outside the three-mile limit with resultant loss to seal-hunters, as well as to a few whalers and hunters of sea otters, who also had been excluded from the waters concerned, these several parties brought suit to recover the amount of their losses. —E. Raymond Hall, *Museum of Vertebrate Zoology, University of California, Berkeley, California.*

RED FOX BREEDING IN SALT MARSH

One of the reasons for the survival of the fox in the heavily populated East is undoubtedly the adaptability of the animal. Normally one would not expect to find a fox breeding in the heart of an extensive salt marsh as such areas would not be expected to have suitable denning sites or adequate escape cover. On a trip to the Bombay Hook National Wildlife Refuge in Delaware on May 25, 1943, however, an unusual opportunity was afforded the writers to observe a pair of breeding red foxes hunting on the refuge. The animals were first observed at about 4:30 p.m. and they seemed to be entirely unaware of our presence for 20 or more minutes. During that time the two animals moved at a slow trot over a zig-zag course away from the observers. After moving out about 300–350 yards one of the animals turned back and came almost to the spot where it was first seen. During this observation period one of the foxes was seen to pounce on prey on two occasions, but both tries appeared to be unsuccessful.

The marsh being hunted is flooded by high tides and retains water most of the time.

The water level was higher in the marsh than usual because of heavy spring precipitation. The only dry places available to the animals were the banks and mounds of sod adjacent to shallow ditches that have been dug in connection with experiments to determine practical methods of mosquito control that could be used without damage to valuable wildlife habitat. The sod mounds measured about six or more feet square.

While the writers speculated as to whether the foxes were breeding in the marsh, a young red fox, not more than one-third grown, was sighted. This young animal apparently was already out hunting on its own as the two other foxes were some distance from it. The young animal was perhaps 100 yards from the nearest sod mound. Because many of these mounds might serve as denning sites, a hurried circuit trip was made around them. A freshly used fox den was found and young had obviously been reared in it as there were numerous droppings of young foxes in the immediate vicinity. The entrance holes were located about three feet above the base of the mound. This was done undoubtedly so that the floor of the den would be above the wet marsh. A cursory examination of a number of droppings indicated that the young had been fed largely on meadow mice, which were abundant in the marsh.

It is of interest to note that when the young fox was frightened by our presence it made its escape in the direction of its parents rather than toward the den.—A. L. Nelson, Clarence Cottam and W. S. Bourn, *U. S. Fish and Wildlife Service, Chicago, Illinois.*

SAY'S BAT IN NEBRASKA

On August 18, 1931, a friend brought me a bat that he had captured near his cottage on Crystal Lake, Dakota County, Nebraska, which is across the Missouri River from Sioux City. The bat had concealed itself between boards leaning against the wall of the cottage. By running through the key in Cory's "The Mammals of Illinois and Wisconsin" I concluded that the specimen was "Say's Bat, *Myotis subulatus* (Say). While Cory's map indicated that this region is well within the normal range of the species, yet there were few records of its capture. The specimen was sent to the late Professor M. H. Swenk, of the University of Nebraska, who concurred in the diagnosis under date of September 10, 1931. Since Prof. Swenk was working on bats at that time the specimen was left in his possession, it is doubtless still in the collections of the University. Prof. Swenk wrote me that it was the first Say's Bat to be taken in Nebraska, and, so far as I know, the record has not been published.—T. C. Stephens, *Morningside College, Sioux City, Iowa.*

THE TYPE LOCALITY OF VULPES MACROTIS NEOMEXICANUS

When describing the type locality of *Vulpes macrotis neomexicanus*, Merriam (Proc. Biol. Soc. Wash., vol. 15, pp. 73–74, 1902) stated it as "from San Andreas Range, New Mexico (about 50 miles north of El Paso)." Bailey (N. Amer. Fauna no. 53, 1931, p. 298) gives the measurements of a New Mexico desert fox "collected near the type locality at Parker Lake on the east slope of the San Andres Mountains. . . ." Poole and Schantz (U. S. Nat. Mus. Bull. 178, p. 51, 1942) describe the type locality as "Band's ranch, San Andreas Range, Dona Ana County, N. Mex. (about 50 miles north of El Paso, Tex.)."

These statements led us to inquire of local ranchers and others conversant with this area regarding this type locality. A search of available local maps also failed to reveal the location of "Band's ranch." There is, however, an old-established Dona Ana County ranch, now controlled by Walter Baird, that fits the description of the locality and that has long been known as "Baird's ranch." This ranch covers many sections of land on the eastern side of the San Andres Mountains on and adjacent to the northeastern corner of the San Andres National Wildlife Refuge and adjacent to the White Sands National Monument. Because of the similarity in spelling of the two names in question and the consequent chance that a spelling error had become established, as well as the similarity of location, the above observations were submitted to Dr. H. H. T. Jackson of the Washington office staff of the Fish and Wildlife Service. Under date of January 8, 1944, Dr. Jackson, who had kindly collated the labels and other records of the type wrote in part as follows,

"It would, however, be very easy to mistake as "Band's" a poorly written "Baird's" on the temporary label and thus transcribe the error to the catalog. This I assume is what was done, and I have accordingly had changed the catalog, labels, and other records to Baird Ranch, which is undoubtedly the correct locality."

As noted above, the spelling of "San Andres" has caused some confusion. Our reference in this regard is the 1916 edition of the Point of Sands Quadrangle, New Mexico, of the U. S. Geological Survey, which quadrangle includes part of the San Andres Mountains, as well as part of Baird's ranch.—ARTHUR F. HALLORAN, *San Andres National Wildlife Refuge, Las Cruces, New Mexico.*

A BEAKED WHALE STRANDED ON THE COAST OF BRITISH COLUMBIA

An anonymous note in Progress Reports of Fisheries Research Board of Canada, the Pacific Coast Stations, No. 49, September, 1941, called attention to the stranding on May

PLATE 1

A beaked whale stranded on the coast of British Columbia. Estevan Point, Vancouver Island, May, 1941. Bones match *Ziphius*—Cowan

25, 1941, of a beaked whale near Estevan Point, Vancouver Island, B. C. This whale was photographed by Mr. B. H. Robson of Estevan but unfortunately did not come to our notice until four months after its stranding.

At that time, through the co-operation of Dr. G. C. Carl, Director of the Provincial Museum, E. Cooke of the Museum staff travelled to the site only to find that the skeleton had been broken up in a recent storm. He was able to obtain the hyoid bones, a small fragment from the posterior part of the mandible and one rib. These and the photograph were sent to Dr. Remington Kellogg of the United States National Museum for comparison with material at his disposal.

One of the throat grooves characteristic of the *Ziphiidae* is apparent in the photograph and this coupled with the form of the few skeletal remnants leaves little doubt of the family represented. Under date of January 2, 1942, Dr. Kellogg writes "The hinder end of the right mandible matches very well with the corresponding end of a *Ziphius* mandible. I

find that the hyoid bone on our mounted *Ziphius* skeleton corresponds in all essential details with the one forwarded for examination." However, despite the similarity in these parts, the very short beak and pronouncedly bulbous forehead seem to set this specimen apart from any others of which figures are available. Comparison of the present specimen with the figure of an adult male *Ziphius* (Stejneger 1919, U. S. Nat. Mus. Bull. 73, Pl. 41, fig. 4) will emphasize this.

The Estevan specimen is in structure of forehead and beak completely unlike *Berardius* and *Mesoplodon*, both of which have a long slender rostrum. The closest resemblance is with fig. 3, Pl. 41 of Stejneger, which represents a specimen, doubtfully *Ziphius*, stranded at Kiska, Alaska in 1904. The major difference between the Kiska specimen and that from Estevan lies in the much more bulbous forehead of the latter. This may well be an age character.

In the original note referred to above the present specimen was referred to the Atlantic species *Hyperoodon rostratus*, but this was later corrected (*op. cit.* no. 52).

I am indebted to Dr. R. E. Foerster, Director of the Pacific Biological Station, Departure Bay, B. C. for the photograph of the Estevan specimen.—I. McT. Cowan, *Dept. of Zoology, University of British Columbia, Vancouver, B. C.*

THREE SHREWS, CRYPTOTIS PARVA, EATEN BY A FERAL HOUSE CAT

About 4:00 p.m. on the clear day of January 10, 1943, a feral house cat was shot along a roadside bordering a mixed grass prairie eight miles northwest of Indiahoma, Comanche County, Oklahoma. An examination of the stomach by myself indicated the cat had eaten the following: 1 *Peromyscus maniculatus bairdii*, 1 *Reithrodontomys fulvescens intermedius*, and 3 *Cryptotis parva*. The mammals had been chewed but were mostly entire. This is the first time *Cryptotis* and the second time *Reithrodontomys* have been recorded in a series of 223 feral house cats collected by the writer in Oklahoma, including the 107 house cats on which McMurry and Sperry previously reported (*Food of Feral House Cats in Oklahoma, A Progress Report*, Jour. Mamm., vol. 22 no. 2, pp. 185–190, 1941).—Frank B. McMurry, *Fish and Wildlife Service, Wichita Mountains Wildlife Refuge, Cache, Oklahoma.*

SPEED AND ENDURANCE OF THE COYOTE

The account of a coyote's remarkable speed of 43 miles an hour and endurance at a lesser speed for 47 minutes, recorded by R. Scott Zimmerman (Jour. Mamm., vol. 24, no. 3, p. 400, August 1943), brings to mind another instance that seems worthy of placing on record.

On September 15, 1942, the writer—in company with Refuge Superintendent John C. Scharff, and Messrs. Paul T. Kreager, Cecil S. Williams, and Clarence A. Sooter—observed an adult female coyote running at nearly full speed on a large artificial dike between two bodies of water at Malheur National Wildlife Refuge, Oregon. The dike ended abruptly in Malheur Lake. Upon reaching the water, the coyote wheeled around and ran in the direction from which it had come. As soon as the observers' car could be turned around, hot pursuit of the coyote was resumed. To keep as far from the car as possible, the coyote followed close to the shore line although most of this border zone was covered with a dense 12-inch stand of saltgrass, which obviously made the running much more difficult. The return chase extended for 2 miles, and during the last 0.6 mile the coyote ran at the surprising rate of 35 miles an hour.—Clarence Cottam, *Fish and Wildlife Service, Chicago, Illinois.*

THE PELVIC GIRDLE OF PARASCALOPS

The absence of a pubic symphysis in the greatly reduced pelvic girdle of adult moles and the location of the urogenital and alimentary canals ventral to it, has been observed generally. There are varying degrees of separation of the pubic bones among the different genera of moles but in adult *Parascalops* an interval of one-half millimeter is usually present between these bones at their nearest points.

Hisaw and Zilley (Jour. Mamm., vol. 8, no. 2, pp. 115–118, 1926) observed that in *Scalopus* the adult condition of the pelvic girdle was a modification during embryological development of a pelvic girdle of the usual mammalian type and that a well developed cartilaginous arch is present ventrally in the pubic region enclosing the urogenital and alimentary canals within the pelvic ring in the 20 mm embryo.

In serial sections of 24 mm *Parascalops* embryos, the above condition is duplicated. The pelvic cartilages meet ventrally and fuse for a distance of approximately one-third of a millimeter.

In nestling moles several days old, serial sections show the condition of the pubic symphysis to be essentially the same as in the 24 mm embryo, the pelvic cartilages fusing for slightly more than one-half millimeter. Thus, even in the newborn mole the urogenital and alimentary canals are contained within the pelvic ring and the subsequent modifi cation of the pelvic girdle of *Parascalops*, by means of which the above canals come to lie outside the pelvic ring, is therefore a post-natal development.—W. Robert Eadie, *Cornell Unniversity, Ithaca, New York.*

THE GENUS PEROMYSCUS IN WEST VIRGINIA

For the past five years, the writer has had the opportunity to study rather closely the habitat and distribution of the species of *Peromyscus* occurring in West Virginia. During this period certain data have come to light that seem worth recording.

Since there is but one published record of *Peromyscus maniculatus bairdii* (Hoy and Kennicott) for West Virginia, its range within the state is still imperfectly known. Two specimens were collected by Karl Haller on March 24, 1937, in Ohio County. This record extended the range of this mouse eastward from Central Ohio to the northern panhandle of West Virginia. Hooper (1942) has commented upon the status of *bairdii* in Michigan, pointing out that if settlement and agricultural activities continues in the eastern United States, its range may come into contact with *nubiterrae* in the Appalachian Mountains. The collection of *bairdii* in West Virginia seems to substantiate these conclusions, in part at least, and intensive collecting may reveal its presence in the central part of the state.

Peromyscus maniculatus nubiterrae Rhoads is a forest dweller, avoiding contact with any type of civilization. Altitudinal records indicate that this mouse is uncommon between 900 feet and 2,800 feet, being most abundant above 3,000 feet. The lowest altitudinal record is 900 feet, near Morgantown.

Generally *nubiterrae* prefers the drier situations found in the forest. They have been found around rock crevices, ledges, talus, piles of lumber, fallen brush, logs, etc. Kellogg (1937, p. 465) reports that "in the vicinity of Cheat Bridge they were trapped at the entrances to holes in the moss covering the roots and base of trunks of spruce trees." Other small mammals collected in the same habitat as *nubiterrae* were *Clethrionomys gapperi carolinensis*, *P. l. noveboracensis*, *Blarina brevicauda talpoides*, and *Sorex fumeus fumeus*. There are no records from buildings or dwelling houses. When the range of *nubiterrae* is plotted on a map it becomes evident that it occurs in that region of West Virginia receiving the most rainfall, yet it seeks the drier situations in these forests. At present there are but few records westward from the Alleghenies.

Peromyscus leucopus noveboracensis Fischer may be found in every county of the state at all altitudes, as it is one of our most common native mice. Previously it was considered a forest dweller, but recent collections reveal that it is found in a variety of habitats. In deciduous and mixed forests, under 3,000 feet elevation, *noveboracensis* is found under fallen logs, stumps, piles of brush, crevices in rock ledges, and the exposed roots of trees along small streams. Other small mammals collected in the same habitat were *Blarina*, *Sorex fumeus*, *Sorex cinereus*, and *Clethrionomys*. In Monongalia County both *noveboracensis* and *nubiterrae* were collected under a pile of discarded lumber at 900 feet elevation.

Above 3,000 feet elevation in mixed forests of hemlock, yellow birch, and spruce, the picture is only slightly different. In Pocahontas County, at Spruce, traps set under fallen spruce logs in the runways of *Clethrionomys* yielded *noveboracensis*. Other mammals

collected in this habitat on the same occasion were *Sorex fumeus, Sorex dispar, Clethrionomys, and Napaeozapus insignis roanensis.*

Generally this deer mouse does not invade meadows or cultivated fields, but confines its efforts to the margins where there is abundant cover. During droughts, however, the situation is slightly different, possibly brought on by a lack of food. During dry fall seasons in the South Branch Valley the writer has collected them under corn shocks and hay stacks. In the fall of 1939, they were quite commonly collected in the long, dry grass growing along the edges of the University High School campus in Morgantown. In 1942 one specimen was collected in a dry pasture field in a trap set in the runway of *Microtus.*

Rather frequently specimens have been taken in the brushy borders of bogs. In Hardy County they were found to be common in a dense stand of *Rosa carolina.* The plants bordered a small bog that was completely surrounded by a large area of meadow. Both *Blarina* and *Microtus* were collected on the same occasion. At Droop Mountain State Park, in Pocahontas County, a series of 15 specimens was collected in *Crataegus* thickets bordering a bog. In March 1940, Mr. J. Lloyd Poland collected thirteen pellets, along with other discarded material, of a short-eared owl, *Asio flammeus,* in a marsh near Charlestown. Examination of this material revealed 27 partial and complete small mammal skulls, of this number 5 were recognized by the writer as being *Peromyscus.*

Conservation officials are faced with the proposition of controlling this rodent in the cabins of the various State Parks. So thoroughly do they like the shelter afforded them that they make it their permanent abode. No article of food, personal clothing, bed clothing, linens, or baggage is safe from the depredations of this mouse unless it is placed in an inaccessible place. Great damage has been done to blankets, pillows and mattresses. Any of these materials may be used in the construction of a nest that may be placed anywhere in the cabin.

It is a mistaken idea that this mouse is not found far from forest cover. Recent collections reveal that it may inhabit stores, houses, and warehouses within a town or city limits. Often the animal's pelage is so stained with coal dust that it is barely recognizable.

In summing up the differences between the habitat of *noveboracensis* and *nubiterrae* it becomes apparent that the latter remains exclusively an eastern mountain forest form. Its range may become restricted by land use. On the other hand *noveboracensis* is slowly becoming adaptable to the inroads of civilization and the conversion of land for agricultural purposes. Its range has not been restricted by land use and it is least specialized in its choice of habitat.

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L. WAYNE WILSON, *Moorefield, West Virginia.*

CORRECTION

A note on the New England cottontail in Maine in this journal (vol. 25, no. 2, pp. 193–195, May, 1944) contains certain errors as follows. The cottontail was listed for the state by Hitchcock as early as 1862 (Proc. Portland Soc. Nat. Hist., vol. 1, p. 66), although this record seems to be a questionable one. Cottontail data in the note by C. M. H. (Forest and Stream, 1893, vol. 40, p. 295) do not apply to Maine.

The writer had prepared a correct manuscript for publication, but the earlier one, containing the above errors, was printed by mistake while he was on combat duty overseas.—LT. (JG) RALPH S. PALMER USNR, *Naval Hospital, Portsmouth, Virginia.*

REVIEWS

Osgood, Wilfred H. THE MAMMALS OF CHILE. Zoöl. Ser., Field Mus. Nat. Hist., vol. 30 (pub. no. 542), 268 pp., December 28, 1943. Price $1.75.

One hundred and twenty-nine kinds (15 new) of native wild mammals, exclusive of the Cetacea, are recorded from Chile, a country which covers nearly 40 degrees of latitude or as much as the distance in North America from Central Mexico to Central Alaska. Along this Coast of the mentioned part of North America there are several times as many kinds of mammals as are recorded from Chile whose mammalian fauna, therefore, may be thought of as relatively small. Chile, all on the west side of the Andes, is divided into 5 faunal districts. "The majority of the mammals are either hystricomorph rodents of long standing in South America or invaders belonging to several families from North America. The minor elements are (1) the caenolestid marsupials directly descended from the early Patagonian fauna and (2) the mouse opossum and several bats . . . from tropical South America."

No less than eight genera are confined to Chile, nearly all to the middle part where the high wall of the Andes shuts them in. The mammalian fauna of Tierra del Fuego is more notable for the number of mainland species that have not reached it than for the number of kinds peculiar to it, and other islands are regarded as having only slight faunal peculiarities.

Although not written for the casual reader, he will, nevertheless, find several of the accounts interesting, as for example, that of how Osgood obtained two Darwin foxes where residents believed there were none, and how the huemul (deer) lacks wariness, as well as in the significant natural history information recorded for several species. One of these, the Patagonian tuco tuco, a burrowing rodent about the size of a large pocket gopher, and formerly abundant, "is now either quite extinct or so near it that its preservation beyond a few years is very unlikely. . . . Practically the whole of southern Patagonia east of the mountains is now in private ownership completely fenced and devoted to sheep raising. . . . The extinction [welcomed by the sheep owners] . . . has required no effort on their part, the mere presence of the sheep being sufficient to accomplish it." It is interesting that the pocket gopher, in some ways the ecological counterpart of the tuco tuco, increases in many areas of western North America where sheep are grazed. Some other kinds of North American wildlife, of course, are affected in the same way that the tuco tuco is in South America, and it is partly on this account that more than a few biologists think sheep should be excluded from more of our western wildlands.

A good account of the history of mammalogy in Chile is given beginning with the writings in 1782 of Molina, and continuing with explanation of the work done by Poeppig, Darwin, Gay and others down to the time of Osgood's visits in 1922 and 1939. From 1853 to 1890 the dominant figure was Rodalpho Amando Philippi who in that time published no less than 30 papers on the mammals of Chile. The last one of any size was published in 1900 when Philippi was 92 years old and Osgood characterizes it as "one of the most extraordinary publications ever to find its way into print. In it he describes and figures in color a total of sixty-three Chilean rodents and proposes sixty-three new names of which no less than fifty-nine are synonyms or quite unidentifiable."

It was Osgood's personal study of Philippi's many type specimens, nearly all still preserved in the Museum in Santiago, that has permitted clarification of the nomenclature of Chilean mammals. The service in this direction is very large, for Chilean mammalogy alone, and also for a much wider area because Osgood's allocation of Philippi's names greatly simplifies the application of names to mammals in regions adjoining Chile. It is doubtful if anyone else working at the present time could have done as good a job as has Osgood who, it will be remembered, rendered a similarly outstanding service to North American mammalogy when he completed the Herculean task of bringing order out of chaos in the genus *Peromyscus* (North American Fauna no. 28, 1909).

The entire paper is of a high order of excellence. It is thorough and conservative. It

is well printed and easy to read. Inclusion of keys, line-drawings of skulls, terse characterizations of each full species or of a representative of each species-group, vernacular names, clear distribution maps, adequate index, and other features which make for usefulness and completeness clearly mark this as the best technical treatment of South American mammals that has appeared in many years. The author and the Chicago Natural History Museum are to be highly praised for the excellence of this published work.—E. RAYMOND HALL.

Young, Stanley P. and Edward A. Goldman. THE WOLVES OF NORTH AMERICA. The American Wildlife Institute, Washington, D. C., xx + 636 pp., 15 figs., 131 pls., 7 tabs., 1944. Price $6.00.

This monograph is written in two parts. Mr. Young, who served many years with the Division of Predator and Rodent Control of the U. S. Fish and Wildlife Service, is author of Part I, which treats the history, habits, economic status, and control of wolves. Part II, treating the classification of American wolves, is the work of Mr. Goldman, recently retired from the Division of Wildlife Research of the U. S. Fish and Wildlife Service.

Part I is divided into the following chapters: Introduction; Distribution of the Wolf in North America, Past and Present; Habits and Characteristics; Natural Checks, Parasites, and Diseases; Economic Status; Measures Used in Wolf Capture and Control; Brief History of Wolf Depredations and Cooperative Federal Wolf Control. Perhaps some measure of the viewpoint of the author is gained from the fact that some 220 pages, of his section of 385 pages, are devoted to the topics of economic status and control.

The first three chapters are interesting, informative, and reveal a thorough knowledge of wolves on the part of the author. He has recorded there a virtual storehouse of information on their habits and life history. These sections alone are worth the price of the volume.

The chapter on History of Wolf Depredations and Cooperative Federal Wolf Control and the one on Economic Status are of interest because they are replete with testimonials of depredations to live stock and the success of Federal trappers in eliminating wolves, ostensibly a saving of money for the stockmen. This is interesting reading, but the reviewer was continually asking himself: "What monetary savings accrued from predator control? What were the costs?" The author makes no attempt to supply details, but the reader is informed (p. 384) that approximately three decades have passed since the Fish and Wildlife Service inaugurated predatory animal control work. "During this time many of the States and counties have repealed their bounty laws, and in lieu thereof have legislated modest appropriations for cooperation with the Federal Government. These monies have been further supplemented by funds raised cooperatively through direct assessments on livestock, in addition to contributions at times from private stockmen and farmers, either in cash, labor or materials."

Not satisfied with this lack of details, the reviewer looked elsewhere and found that the annual cost of predator control and its corollary, rodent control, to the public each year is, as estimated for the four years 1935–1938, as follows:

Year	Federal Appropriations	State Funds	County and Local	Federal Emergency Funds	Total Available
1935	$441,354	$253,365	$619,374	"about 900,000"	$2,214,093
1936	599,482	305,381	730,089	"about 1,000,000"	2,634,952
1937	594,531	382,673	903,919	1,125,800	3,006,923
1938	609,022	456,324	818,598	512,877	2,396,821

No comparable figures are available for the last few years, but that the cost has not decreased is suggested by the size of Federal appropriations: **1942.** $949,300; **1943.** $784,550; **1944.** $847,000; **1945.** $865,000. And post war plans of the Fish and Wildlife Service (see Conservation News, p. 4, January 2, 1945) call for the expenditure of $4,000,000 a year for a three year period!

Perhaps the reviewer is one of those "certain nature lovers, with a highly theoretical concept of a biological balance" to which Mr. Young refers (p. 384). If so, he is one of many who through simple processes of deduction can see that if we Americans continue the program of predator destruction, we will have forever with us the corollary problems of eradicating rodents and rabbits on which predators subsist, and of managing surplus populations of big game animals that predators certainly keep in check, both of which may be far more destructive of basic values through overgrazing and accelerated soil ersoion than the sum total of depredations by wolves to livestock. To the reviewer, it seems that the omission of a complete economic and ecological picture of the wolf detracts from the value of the book.

"Today, the wolf has been definitely brought under control and presents a very minor problem except in limited areas in the United States, in connection with man's interests . . . Except in local areas where wolves have continued to present a pressing economic problem the Fish and Wildlife Service has felt that little wolf control work is now justified. There still remain, even in the United States, some areas of considerable size in which we feel that both the red and gray species, in their respective habitats, may be allowed to continue their existence with little molestation" (p. 385).

These are pleasant tidings to those "certain nature lovers", but I fear they are mere words, never to be translated into the working policy of the Fish and Wildlife Service. Furthermore, it is nearly time to prepare the obituary for the gray wolf in the United States. "At present [1943], . . . it is questionable whether any [gray] wolves now occur in South Carolina, Montana, Idaho, California, Nevada, Utah or Wyoming" (p. 56). The author might well have added to the list the states of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Colorado, Texas, Iowa, and Missouri, as well as most of the states east of the Mississippi River. A few wolves still cross from Mexico into Arizona and New Mexico, but *alert government trappers* are on their trails immediately. A small group still occurs in eastern Douglas County, Oregon, but they, too, are continually persecuted. Wolves that cross from Canada are immediately caught by government trappers, except, perhaps, in the Great Lakes region.

Fortunate indeed will be the citizen of tomorrow who sees a gray wolf in the United States in its native haunts. And so ends the saga of 25 years of *conservation*!

Part II treats systematically the 23 geographically varying races of the gray wolf (*Canis lupus*) and the three races of the red wolf (*Canis niger*). This section is divided into the following chapters: Introduction; History; General Characters; Pelage and Molt; Variation; Explanations; List of North American Species and Subspecies, with Type Localities; Canis lupus and Subspecies; Canis niger and Subspecies.

After carefully reading the text, the reviewer finds difficulty in distinguishing with certainty between gray and red wolves, and between red wolves and coyotes. For example (p. 416): "Some specimens of *C. l. lycaon* [gray wolf] . . . are of about the same size as *C. n. gregoryi* and *C. n. floridanus* [red wolves], and while the pelage is longer, the color may not be very different. Similarity is also remarkably close in most other respects. Even the skulls are very much alike in form and in dental details. The most reliable distinguishing characters seem to be the reduction of the cingulum on the outer side in the first upper molar, the less deeply cleft crowns and more rounded, less laterally compressed cusps of the large molariform teeth. All discernible characters are subject to individual variation that may tend to obscure true relationship. It seems evident, however, that the cranial and dental similarities are supreficial, with no direct bearing on specific distinction."

As regards *Canis niger* and the coyote, *Canis latrans*, the author says (p. 481): "Subspecies *rufus* in central Texas and Oklahoma . . . is so small and in general characters agrees so closely with *C. latrans*, which it overlaps in geographic range, that some specimens are difficult to determine. . . . Owing to wide range of individual variation . . . some of the smaller specimens of subspecies *rufus* may be confused with larger examples of *latrans*. Specimens collected in the vicinity of Llano, Tex., include typical examples of both species and individuals not sharply distinctive of either." The author suggests that such individuals may be hybrids.

These comments reveal the difficulty of the group from a taxonomic viewpoint and are some measure of the complexity of the problem to which Mr. Goldman has made no small contribution. This revision of the wolves is most welcome and constitutes a distinct advance in the knowledge of the relationship of North American wolves.

Obvious errors and inconsistencies have crept into the book. For example, the citations to the Journal of Mammalogy in Part II are written "Mamm. Jour." in seven instances, as "Jour. Mamm." in three instances, and as "Journ. Mamm." in two instances. On page 469 the name of the Mexican Wolf is given as Canis Lupus Bailey; on page 524 the date 1938 is out of line with other dates on the page. Other inconsistencies involve the usage of "skull without skin" and "skull only" to convey the same meaning; counties are given for some locality records and not for others; some localities are listed which do not occur on any of the maps available to the reviewer—for example: Fort Richardson, Texas; Kruger, Montana; Kendrick Peak, Arizona, etc. Listing the County for each locality record would have saved hours of time for those who have need to plot these records on maps.

The bibliography contains several hundred citations to the vast literature on the wolf. The use of such large type in this section seems a bit incongruous; smaller type would have produced a more pleasing page to the eye and would have saved several pages in an already thick book.—WILLIAM B. DAVIS.

Murie, Adolph. THE WOLVES OF MOUNT MCKINLEY. Fauna of the National Parks of the United States, Fauna Series no. 5, xix + 238 pp., 58 figs. 1944. Price 40 cents (Superintendent of Documents).

The author of "The Wolves of Mount McKinley" needs no introduction to those individuals interested in the life history and ecology of the larger carnivores. His "Ecology of the Coyote in the Yellowstone" published in 1941 placed him among the foremost American ecologists, and the present contribution contains nothing to weaken that position.

Based upon field studies conducted by the author from April 1939 to August 1941, the observations and records of the Mount McKinley National Park personnel over a period of more than 20 years, the experiences of "old timers", and specimens, the author has woven a remarkably comprehensive picture of the part the Alaska Wolf (*Canis lupus pambasileus*) plays in the everchanging interrelationships among the wild animals of Mount McKinley National Park. Although the wolf assumes the lead in the drama unfolded, Dall sheep, caribou, moose, grizzly bear, red fox and golden eagle make up a strong supporting cast, with the lesser creatures playing minor roles. The plot centers around the ceaseless struggle for life—the struggle against starvation, disease, the rigorous winter weather, and, in the case of the herbivores, predation.

The wolf family has a "rather definite" home range, which in one known instance encompassed an area "at least 50 miles across"—this in a region where wolves have not been seriously reduced by government control. The home life of the family is one of congeniality among the members and of considerable intolerance to strangers. The so-called wolf pack usually is composed of the immediate family and a few friends, and seldom numbers more than 10 or 12, except in rare instances when two families may join company.

Of particular interest in the relationship between the wolf and its prey species are these comments by the author: "Because so few (mountain) sheep die in their prime, it is obvious that any wolf predation affects mainly the weaker animals." And again, "Wolf predation probably has a salutary effect on the sheep as a species." "In the presence of a large wolf population in recent years, moose have increased in the park and the region adjacent." "Under natural conditions the caribou herds are no doubt adjusted to the presence and pressure of the wolf." In spite of heavy wolf predation some 20,000 to 30,000 caribou live in the area. What more evidence can one desire to establish the fact that the wolf has an important place in Nature?

The report abounds with ecological data on the other animals in the area. In fact, so much other material is presented that a more comprehensive title than "The Wolves of Mount McKinley" might have been more appropriate.

The author is to be congratulated on presenting the facts as he saw them and for having the breadth of vision and experience necessary to present a complete well-balanced ecological picture of the wolf.—WILLIAM B. DAVIS.

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters)

[Reprints of this section can be purchased for 18¢ each from the corresponding secretary]

AMOROSO, E. C., A. E. BARCLAY, K. J. FRANKLIN, and M. M. L. PRICHARD. Incidence of bilateral anterior venae cavae in a series of Eutherian foetuses. Proc. Zool. Soc. London, ser. B, vol. 113, pp. 43–53, fig. 1. July, 1943.

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——— Raising raccoons. U. S. Fish and Wildlife Serv., Wildlife Leaflet no. 251, 2 pp. March, 1944.

——— Montana moose. Montana Wildlife Bull., Helena, vol. 1, no. 2, p. 9. March, 1944.

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COMMENT AND NEWS

ANNUAL MEETING

A poll of the officers and directors of the American Society of Mammalogists has resulted in the decision not to hold a regular annual meeting for 1945; but in its stead, a business meeting of the officers and directors will be held in the Chicago Museum of Natural History, Chicago, Illinois, at 10:00 o'clock a.m., May 12, 1945. The officers and directors will gather in a room adjacent to the office of the Chief Curator of Zoology.

ZOOLOGICAL RECORD

Members of the Society and others working in the field of Mammalogy will be interested to learn that "Natural History Books", 6843 Hobart Ave., Chicago 31, Illinois, has become the American agents for the Zoological Record issued by the Zoological Society of London. The section on Mammalia can be purchased separately.

STUDY OF CYCLES

The Committee on the Award of the Medal of the Foundation for the Study of Cycles for 1944 is now calling for papers published within that calendar year. Five copies of each paper to be submitted for consideration should be sent immediately to the Advisor

for the American Society of Mammalogists, W. H. Burt, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

GOLDMAN RETIRES

After 52 years of service with the U. S. Fish and Wildlife Service (formerly Bureau of Biological Survey), Edward A. Goldman retired December 30, 1944. He will continue his researches on the mammals of Mexico and the United States at the U. S. National Museum.

ACTUAL DATES OF PUBLICATION

The actual dates of publication of the four numbers of volume 25 (1944) of this Journal were: No. 1.—February 18; No. 2.—May 26; No. 3.—September 8; No. 4.—December 12.

OBITUARY NOTICES

Wilbur Stuart Long

1903–1944

Wilbur Stuart Long, a member of the American Society of Mammalogists since 1936, died of a heart attack at Moab, Utah, October 19, 1944. He was born July 11, 1903, at McArthur, Ohio.

His chief interest was ornithology and he was a born collector and fieldman. In 1935 after he received his M.A. Degree at the University of Kansas, he entered the United States National Park Service as Wildlife Technician and later transferred to the United States Soil Conservation Service as Junior Biologist. At the time of his death he was District Conservationist for Grand and San Jaun counties, Utah.—Claude Hibbard.

Theodore Roosevelt, Jr.

Brigadier General Theodore Roosevelt, Jr., member of the Society since 1925, died of heart failure in France on July 12, 1944.